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ART
Art Editor: Fraser McDermott
Image Manipulation: Gary Stuckey
Photography: Future Photo Studio

BUSINESS
Vice President, Sales: Stacy Gaines, stacy.gaines@futurenet.com
Vice President, Strategic Partnerships: Isaac Ugay, isaac.ugay@futurenet.com
East Coast Account Director: Brandie Rushing, brandie.rushing@futurenet.com
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West Coast Account Director: Austin Park, austin.park@futurenet.com
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West Coast Account Director: Tad Perez, tad.perez@futurenet.com
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Tuan
Nguyen

LANDING THE BIG PUNCHES

THIS IS AN IMPORTANT ISSUE for me. But I reckon it's important for the whole PC community. I feel as though this is one of those times when you get to hold a company's future in your hands, literally. I am, of course, referring to our review of AMD's Ryzen Threadripper.

I treat Threadripper as AMD's first halo product in years. Many of the company's recent releases have been iterations on existing products, and while that's great, Threadripper stands on its own as being ballsy.

Here's the thing about halo products: Not many can afford them, and many more people don't need them. I always refer to Audi when talking about halo products, because ever since the release of its R8 supercar, the company changed for the better. Threadripper is AMD's R8. And now is the best time for the company to launch it—and we have it.

Lest you have any doubts, Threadripper is fast—let's get that out of the way. It has an obscene number of discrete cores. It has an outrageous number of PCIe lanes. It has pretty much everything you could ask for from a high-end CPU. But you don't need it.

What you should be buying instead is any of AMD's other Ryzen CPUs. They're plenty fast, they're feature-rich, and they're much cheaper. They're the CPUs that AMD wants to sell in quantity. In fact, it's actually AMD itself who needs Threadripper. Let me explain.

With Ryzen, the community was excited but cautious. Everyone knows that Ryzen is a formidable microarchitecture, and AMD made good on its promise to deliver CPUs in quantity. The problem was the lackluster history of AMD as a platform overall, which is the direct fault of itself and its partners.

To seal the deal, to show that the company is damned serious at being on the offensive, AMD needed Threadripper. And guess what—the strategy is working. Intel is on the defensive now, and it's more than just a feeling: Recent announcements, such as its 18-core CPU and product mix shake-up, tell me I haven't seen Intel being pushed into a corner like this for nearly 18 years.

AMD is showing us and showing Intel that it's a serious threat again. With Ryzen and Vega all coming out within similar time frames, AMD is getting an incredible amount of attention for having a both a working strategy and performance numbers to back it up. The company that was full of doubts before is now full of confidence.

Several issues ago, I said that AMD was back in the ring, and able to exchange bouts with Intel. Now it's several rounds in, and there are visible scuffs and bruises on one of the fighters. But it ain't the one wearing the red trunks.

Tuan Nguyen is Maximum PC*'s editor-in-chief, also known as "the pointy end of the stick." He's been writing, marketing, and raising hell in the tech industry for 20 years.*

↘ submit your questions to: comments@maximumpc.com

THE NEWS

More Core Wars

Intel's $1,999 Core i9, with Coffee Lake to follow—is this enough to match AMD?

EVEN IF YOU HAVE no intention of using an AMD Ryzen or Threadripper, their very existence is good news. It has made Intel respond with faster and better; competition is back. Intel's latest response is high-end Core i9s, available by the time you read this. We now have the skinny on the fastest four.

At the top of the tree is the lovely 18-core i9-7980XE, running at a base clock of 2.6GHz, with a Turbo mode of up to 4.4GHz. As with all the new i9s, we get quad-channel DDR4 and 44 PCIe lanes. Below this, we have a 16-core i9-7960X running at 2.8GHz, the 14-core i9-7940X at 3.1GHz, and the 12-core i9-7920X clocking in at 2.9GHz.

Sounds great, but you can see what's coming, can't you? These are expensive puppies. The i9-7980XE is a wilting $1,999—over $250 more than the priciest i7. The 16-core part is $1,699, the 14-core is $1,399, and the 12-core stops just short of four figures at $999.

Inevitably, these are going to be thrown against AMD's Threadripper, and it'll be tight. Threadripper has the higher base clock speeds, but Intel's Boost tops that. On single-thread applications, Intel will hold bragging rights, so gamers who are after every iota of performance will want one, but it comes at a cost, quite literally. It's a solid reply, but it's no knockout counter-punch.

Meanwhile, we have Intel's eighth generation Core CPU in the pipeline, codename Coffee Lake, which is already in production. These are mainstream six-core chips, and are still built on a 14nm process—we're still waiting on those 10nm chips we were promised. This is the fourth generation Core to use a 14nm process; it looks as though shrinking things is getting tricky and/or expensive.

If leaked slides from Intel are to be believed (often, but not always), we'll have Coffee Lake versions of the i7 and i5 first, all six-core: the i7-8700 and 8700K running at 3.2GHz and 3.7GHz respectively, and i5-8400 and 8600K running at 2.8GHz and 3.6GHz. Quad-core i3 versions won't be far behind: the 3.6GHz i3-8100 and the 4GHz i3-8350. Two-core variants will complete the set. Eventually, Coffee Lake will come in 35W mobile and low-energy versions, a 65W mainstream iteration, and a 95W "enthusiast" version. Intel's teaser claims they will be "blazing fast." More practically, the company is aiming at a 30 percent improvement over Kaby Lake, which would be most welcome if we see it.

> “Gamers after every iota of performance will want one, but it comes at a cost.

intel
CORE i9
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Intel's 18-core Core i9, for when you absolutely must have every ounce of power, and have 2,000 bucks.

The not-so-cheery news is that Coffee Lake will need new motherboards, a modified version of the LGA 1151 socket. The new boards are based around a Z370 chipset, and get 16 PCIe lanes for graphics, and another 24 lanes for high-speed storage, including Intel's Optane tech, of course.

Meanwhile, AMD's mammoth Threadripper has arrived, in all its 4,096-pin glory, along with the first generation of motherboards. Alongside the three Threadrippers we know of, there's a fourth, the 1920 non-X version. A 12-core plain vanilla version of the 1920X, not all of us are going to overclock.

Has Intel regained the high ground? Not quite, and it's being pushed right across the markets, from the lowliest Core i3 to the top-of-the-tree i9. You can argue the merits, features, and performances of each chip, but there's no arguing that AMD does it cheaper. Intel has to respond by either offering similarly good value, or by being faster, and it isn't really managing either right now. **–CL**

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AMD RADEON GRAPHICS

RYZEN

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Work easy. Play hard. Windows

BITCOIN MAKES A HARD FORK

Bitcoin wallets double with new bitcoin cash

Bitcoin has now become bitcoin and bitcoin cash (name could have been less confusing, guys), wallets being populated with an equal number of the new version, creating $4 billion of cryptocurrency overnight. The blockchain has been cloned, known as a hard fork. The nature of the math behind bitcoin means that transactions, and hence new coins, become increasingly more convoluted to make. The original specs have slowed this to a crawl. Bitcoin cash uses the same basic blockchain system as bitcoin, but with much bigger blocks, up from 1MB to 8MB. The bitcoin miners now have something potentially profitable to chew on again.

The arrival of bitcoin cash caused a spike in bitcoin's value, to near $3,500. But, given the volatility of bitcoin, printed valuations are ephemeral.

The split mirrors that of bitcoin's founders and developers as to how to address the speed problem. A large block size eats into bitcoin's distributed nature as hardware requirements increase, eroding its democratic nature. A rival camp backed an update due this fall, called SegWit2x, which also increases block size, but includes off-chain transactions. This has caused ripples, and may lead to another split, as those following the original principles rebel.

Bitcoin has weathered storms before. Last year saw the departure of one of the founders, Mike Hearn, who claimed bitcoin was "a failed experiment," and it was in the hands of a small group of people running the big exchanges and developers, the Bitcoin Core, which goes against the founding principles. He is also said to have sold all his coins, a decision he might now regret.

Money is about trust, and bitcoin's journey to acceptability has been tortuous, but inexorable. Even the fall of the Japanese exchange Mt. Gox, which had 650,000 coins stolen, didn't faze investors much. In July, the FBI caught up with Alexander Vinnik, who allegedly laundered millions through the BTC-e bitcoin exchange, including proceeds from the Mt. Gox hack. Cryptocurrencies are here to stay, but need stability, an elusive quality, for widespread acceptance. **–CL**

PASSWORD RULES WRONG

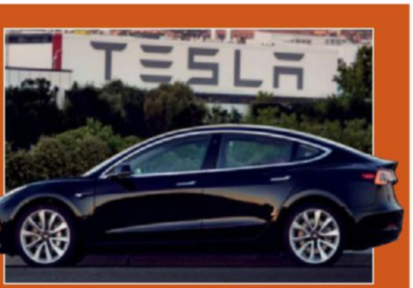
NO MORE ANNOYi%INg PASSWORDS

In 2003, the National Institute of Standards and Technology said passwords should contain upper and lower case letters, a number, a special character, and should be changed frequently. Many services insist you follow this format, leading to passwords that are difficult to rEm3mB%r. Bill Burr, the man behind the rules, has confirmed what many argue is correct: it's about password length. Four random words are more difficult to crack, and easier to recall. NIST has issued new guidelines, which also suggest not changing passwords unless a security breach is suspected.

The old system created passwords that were cryptographically weak, but hard to use. "Much of what I did I now regret," said Bill. To be fair, it was also our fault; we used common number substitutions, and simple base words. Don't get too blasé, though—"mynewpassword" is still not good. **–CL**

500,000 WANT A TESLA 3

Huge demand prompts bond issue



The massive demand for Tesla's new $35,000 Model 3 shows that we are ready for the mainstream electric car—the company had over half a million reservations on its books at one point. This makes it the most anticipated car ever. To fund manufacturing, Tesla has been forced to sell $1.5 billion in bonds, and the money men look happy enough to buy them. Over the first quarter of 2017, it built 25,000 cars, a new record for Tesla, but a long way from its plan for 500,000 a year—even at this level, it is under a tenth of Ford's annual production. Tesla has a lot riding on the Model 3; despite catching the zeitgeist beautifully, the company still made a loss of over $330 million last year.

The list of problems for the electric cars is long, from adequate charging stations to thornier problems, such as securing supplies of cobalt. However, momentum is building—we are going to go electric folks. **–CL**

Tech Triumphs and Tragedies

A monthly snapshot of what's good and bad in tech

TRIUMPHS

✓ **QUANTUM TELEPORTATION IN SPACE**
Chinese scientists have sent a photon 300 miles up to a space station. Unhackable instant Internet still a way off, though.

✓ **HYPERLOOP AT 192MPH**
Elon Musk's magnetic-levitation pod in a tunnel is due for full-scale test in South Korea.

✓ **DISNEY GOES STREAMING**
Next year, Mickey and chums will have their own streaming service, including original content.

TRAGEDIES

✗ **SURFACE WOES**
Consumer Report has stopped recommending the Microsoft Surface after breakage rates reach 25 percent after two years.

✗ **DOTA FANS UNHAPPY**
Valve's new digital trading card game based on *Dota* hasn't gone down well with fans—cue an online hissy fit.

✗ **MORE UBER CHAOS**
One of the company's investors, Benchmark Capital, is suing CEO Travis Kalanick for fraud.

Jarred Walton

TECH TALK

RX Vega Is a Power-Hungry Graphical Beast

LATE LAST YEAR, AMD revealed many of the details behind its Vega architecture. It all sounded great on paper, and frankly I wanted Vega hardware right then. But it wasn't fully ready for release, so we had to wait... and wait. The consumer versions of Vega finally launched in August, and specs are both more and less than what I hoped to see.

Vega has half the memory stacks, up to eight times the VRAM, and a smaller die and package than Fiji.

On paper, there's a lot of good stuff inside Vega. New features include the High-Bandwidth Cache Controller (HBCC), reworked shader pipelines, new instructions, far more VRAM than the previous high-end Fiji design, and a Draw Stream Binning Rasterizer (DSBR). These are designed to allow Vega to outperform all other AMD GPUs, and the result is clock speeds up to 1,677MHz on the liquid-cooled RX Vega64, or 1,546MHz on the air-cooled variant.

Combined with 4,096 shader cores, that gives Vega 13.7/12.7 Tflops of raw FP32 compute performance. Nvidia's GTX 1080 Ti delivers up to 11.8 Tflops, and the Titan Xp up to 12.2 Tflops. That means RX Vega is going to outperform the 1080 Ti, right? Not so fast....

AMD's GCN architecture has always delivered less gaming performance per Gflops of theoretical performance. The 980 Ti is rated at only 5.6 Tflops, compared to the Fury X at 8.6 Tflops, yet in practice the 980 Ti ends up around 5 percent faster (using my benchmarks across a large suite of games). At the unveiling of the RX Vega, AMD made it clear that its competitive target is the GTX 1080, and it might not even come out ahead consistently there.

But the kicker is the power requirements. The liquid-cooled RX Vega64 card will use up to 345W, the air-cooled RX Vega64 295W, and the only "power-friendly" variant will be the Vega56, which gets down to 210W by drastically cutting clock speeds. (There will also be a Vega Nano at some point, but AMD hasn't given any specifics.) In contrast, the 1080 has a 180W TDP, and the 1070 is 150W.

> “If Nvidia performs a bit faster, while using less power, this is a clear win for the green team.

Why isn't Vega the 1080 Ti killer we hoped for? Fundamentally, it all goes back to the architecture. AMD's GCN architecture was designed to be good for compute, and it remains a strong point. Low-level access via APIs such as OpenCL, DX12, and Vulkan often allow developers to tap into the full power of the GPU, while DX11/OpenGL drivers end up being far less effective. But the key to the potential of the GCN architecture lies within the schedulers that queue up work for the GPU cores.

The Asynchronous Compute Engine (ACE) has been part of AMD's GCN architecture since the first HD 7970 rolled off the foundry floor in 2012, but it wasn't until Windows 10/DX12 that the real potential was even realized. Having the ability to be more flexible in scheduling work for the GPU is beneficial, but more robust scheduling is a trade-off between power (watts) and flexibility. We've seen this with 290X versus 780 Ti, Fury X versus 980 Ti, and now Vega64 versus 1080. AMD is close to Nvidia in performance but less efficient in power.

AMD counters the disappointing power draw and performance by going for reasonable prices. While the liquid-cooled Vega64 card carries a healthy premium at $699 (and comes in a pack that includes some games and other incentives), the standalone air-cooled Vega64 will set you back $499, and the Vega56 will cost $399. That's right in the ballpark of GTX 1080/1070 pricing, which is good, but if Nvidia performs even a bit faster, while using quite a bit less power, this is a clear win for the green team.

After a year of waiting since the GTX 1080 launched, AMD's answer seems to be similar performance using 50 percent more power. AMD fans must now await Navi, and hope it can buck the trend.

Jarred Walton has been a PC and gaming enthusiast for over 30 years.

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Alex Campbell

OPEN SOURCE

A Little More Love for Laptop Linux in 2017

EVEN WITH MODERN INSTALLERS for Fedora and Ubuntu, wiping Windows and installing Linux is still a hassle for many Linux users when they buy a new laptop. Those days might be numbered as the number of laptops shipping with Linux slowly grows, but there's still plenty of room for improvement in the user experience.

Linux is the number-one kernel on the planet. It runs on everything from IoT devices and cell phones to high-end supercomputers. Yet life with Linux on a laptop has often been full of compromise. Nvidia drivers still don't play nice with Wayland. ACPI power management can be hit or miss. And Wi-Fi can still cause headaches sometimes. Even so, Linux is far better on laptops today than it was five years ago.

Historically, hardware woes could be avoided by looking for hardware that was compatible with Linux before buying. Since manufacturers didn't exactly advertise Linux compatibility, it was up to the user to figure out the make, model, and revision of the key pieces of hardware in a laptop. But this can be tricky, because manufacturers rarely list the hardware in that much detail on their web stores.

That trend is slowly changing, however. Dell has a growing line of PCs for "developers" that come with Ubuntu Linux and Linux-friendly hardware. The lineup isn't too shabby, either: Dell has Linux machines ranging from the XPS 13 Developer Edition to the Precision 5720 desktop all-in-one. Depending on the model, you can get a laptop with an i7 or Xeon CPU, and loads of RAM, that launches Ubuntu's setup on the first boot. That's nice. Really nice. But still, the developer offerings are only a fraction of Dell's product offerings, and many have to be purchased through Dell's business sales website. I also have yet to find discount portals (for things such as student discounts) for any of the developer models.

Pop! OS: Ubuntu Gnome with a flat theme. Credit: System76.

But Dell isn't the only player. Boutique Linux PC maker System76 has an impressive line of laptops as well. Though lacking the svelte carbon fiber appearance that graces Dell's PCs, System76's machines do compete in terms of power and features. (The Galago Pro has an RJ-45 Ethernet port on the right that collapses down when not in use to preserve the PC's thin profile.)

System76 has gone one step further than Dell, too: Recently, System76 released a beta version of its own OS, dubbed Pop! OS. When I took a look at it, Pop! was little more than Ubuntu Gnome with a custom desktop and color theme. Even so, the fact that a PC manufacturer took the time to extend its branding by customizing an OS is worth notice.

No matter how good these machines are, the laptop world is still dominated by Windows. Even ThinkPads that have been a reliable choice for mobile Linux users still come with Windows. Luckily, Linux has gotten easier and easier to install. Ubuntu and Fedora have newbie-friendly graphical menus that guide the user through installation. Even Arch, which is notoriously tedious to set up, can be easily installed by using the derivative OS Manjaro. I should also note that Fedora's USB writing tool for Windows is the easiest and most foolproof way to write a bootable USB stick I've ever seen, yanking the barrier to entry yet lower.

Even though it has gotten easier to install Linux, paying the Windows tax and banishing Windows from your SSD will endure for the vast majority of laptop models on the market. But if Dell or System76's offerings catch your eye, you can bypass the setup BS and get back to actually using your PC.

Alex Campbell is a Linux geek who enjoys learning about computer security.

THE LIST

TOP TECH FROM SIGGRAPH 2017

8

RADEON RX VEGA

At last, AMD removed the wraps from its Vega GPU—three flavors, 13.7 teraflops, and a whole lot of pixels.

7

RADEON PRO SSG

RADEON WX SSG

Not as muscular as the gamer Vega, but an integrated 2TB SSD makes 8K video editing realistic at last.

6

NVIDIA EGPU

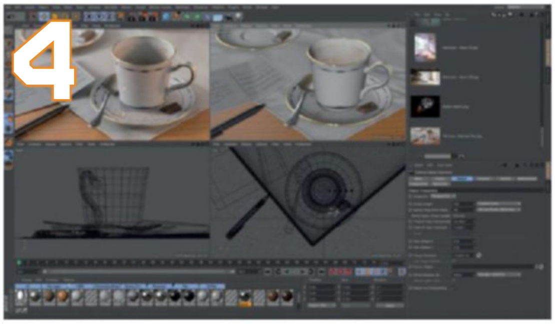
It's official: Nvidia and partners will produce a Thunderbolt 3 external GPU solution for Titan and Quadro cards.

5

NVIDIA ISAAC

Nvidia stepped beyond GPUs with its AI-controlled robot, which can play dominos or be a VR telepresence avatar.

4



CINEMA 4D R19

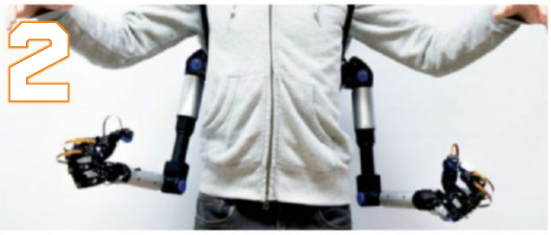
Maxon's renderer update introduces GL-bolstered real-time previews, a spherical VR camera, and stacks more.

3

HP Z VR BACKPACK

HP's pro take on its Omen backpacks, aimed at theme parks and "experiences," squeezes immense power into a 10lb pack.

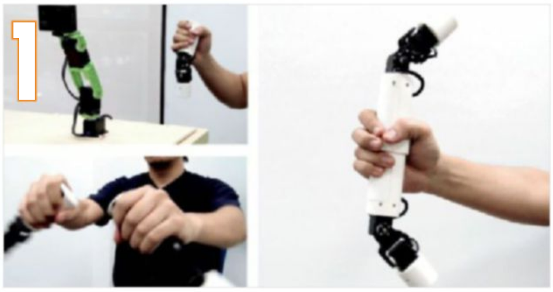
2



METALIMBS

Not enough arms? These foot-controlled add-ons from Japan's Keio University have 10 extra fingers for you.

1



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HEAD TO

BY IAN EVENDEN

Photoshop CC vs. Photoshop Elements vs. Affinity Photo

Anyone editing photos in free apps will soon hit the limits of their chosen program—unless that program happens to be GIMP—and will be looking to move on to something with more power, more freedom, and more toys to play with. Software giant Adobe has traditionally held all the cards, its Photoshop Elements and Photoshop covering the range from casual to professional use. But a new challenger entered the arena last year, with Serif's reasonably priced Affinity Photo making the jump from Mac to Windows. So, which is best?

ROUND 1

Image Manipulation

They're all really, really good for this. Seriously. It's what they're made to do. We couldn't get an M2 SSD between them, so tightly are they clustered around the "really good" end of the scale. If pressed, we'd say we like the Adobe way of working, especially the behavior of the Crop tool, over Serif's. But that could be 20 years of professional use talking. So, let's talk about pricing. Photoshop CC is part of Adobe's notorious subscription pricing model, which puts some people off. However, the Photographer's Bundle nets you Photoshop and the raw image development/organization app Lightroom, for $20 a month—looked at like that, maybe it's not so expensive. Elements and Affinity are buy-once apps, and while Elements gets annual upgrades, which may extract extra cash from you if you're determined to always have the latest version, Affinity has been receiving regular free patches and updates since its launch, with no version 2.0 on the horizon. If you're planning to process images for print, be aware that Elements is the only app here that can't convert to the CMYK color model. Other than this, it's got 90 percent of Photoshop's power.

Winner:
Photoshop CC

ROUND 2

Raw Image Files

Serious cameras shoot raw files. And so do a lot of compacts, cell phones, and action cams. A raw file is the unaltered data from the sensor, written straight to a camera's memory card, bypassing the expensive processing circuitry. Your PC then processes it, with you taking full control. Adobe Camera Raw is the processing interface you'll find in Photoshop CC—it even has its own app, Lightroom—and it's richly featured and kept right up to date with the latest camera releases. There's a cut-down version of it in Photoshop Elements, which keeps the most important tools, and dispenses with those that it's merely nice to have. Affinity Photo dedicates an entire "Persona"—its term for dedicated modes of operation that change its whole look and interface—to raw processing, and its tabbed interface means that you can work on a raw file in one tab and a JPEG in another, if that's your thing. Affinity's raw processor received a large upgrade in the 1.5 release of the software, and is now much more on a par with Photoshop's, even though the two companies sometimes call the same adjustment a different name.

Winner:
Affinity Photo

ROUND 3

Text

All three apps handle vector text using the fonts installed on your PC, and have tool palettes dedicated to the manipulation of those letters and numbers, very much like those you would find in a page layout application. Raster image editors aren't the best choice for setting lots of small text, but it's nice to know the option is there. Affinity splits its text tool into two, with single lines of Art Text that can be styled as you choose, or container frames filled with paragraphs of closely set body text. Font previews are instant, and there's a live spellchecker, too. The Adobe apps have one Type tool, but it works the same way as Serif's. Click to get a line of text, style it up, and select its size, or drag out a box with the same tool to fill with smaller type. You can select antialiasing options to prevent jagged edges, and all text is placed on its own layer, opening it up to the full range of layer effects—although you may need to rasterize it first. One thing Photoshop has that Affinity doesn't is the ability to place text along a path, leading to curved headlines or logos that run in circles. Serif's vector graphics app, Affinity Designer, does have this capability, however.

Winner:
Tie

HEAD

Photoshop CC is a gray, austere-looking program that doesn't hold your hand.

Photoshop Elements has modes for newbies and talks you through the editing process.

Affinity Photo comes with loads of YouTube-based tutorials, but can be baffling at first.

ROUND 4

3D

There is really only one viable choice if you're serious about 3D, and that's Photoshop CC. The other apps can create 3D text effects, or be used to paint textures, or import them from photos, but Photoshop has a dedicated 3D workspace that enables you to create 3D extrusions from 2D artwork, or use pre-set shapes to build a 3D mesh, building up to nine different texture map types to define its surface. It's not as powerful, nor as intuitive, as a dedicated 3D application would be, and it also relies on you owning such a program in order to directly edit the polygons of any complex 3D meshes you may have imported using several common 3D formats—AE, OBJ, 3DS, U3D, and KMZ. You can, however, view your meshes in a variety of render modes, scale and rotate, cast lights upon them, and import several meshes into one scene. Flat 2D layers can be wrapped around a 3D object, and a depth map can be generated from a grayscale image. Finally, you can render and export your creation as common 3D file types—however, if your scene is quite complex, you'll have to wait while your PC chews through all the data.

Winner:
Photoshop CC

ROUND 5

Web Graphics

Some might say that any program that can export a transparent PNG file can be used to create web graphics, but there are obvious benefits to using a photo editor. This is one area where full-strength Photoshop might not be the best option, because you're working in largely low-res workspaces, and not using too many clever tools. Adobe recently updated Photoshop CC's ancient "Save for Web" export panel, which was based on code from the even older Adobe ImageReady, and shuffled it off to Legacy status. The new "Export" menu supports Photoshop's latest features, and while "Save for Web" is still in there, the new method should be faster. Elements keeps the "Save for Web" dialog, giving you the options to compress and dither your graphics to get the absolute smallest file size at the best quality, and showing you previews of what the final result will look like. Affinity, as is often the case, dedicates a whole Persona to exporting images, changing the look of the app to bring the tools you need right to your fingertips. There are presets you can use, or you can set your own options to get something that works for you.

Winner:
Tie

And the Winner Is...

It's tricky to pick a winner when the answer to the question "what do you need an app to do?" can differ so wildly. Photoshop CC ($20 a month) is a sledgehammer, especially when bundled with Lightroom, that guarantees the absolute best in terms of tools and image quality, and can crush any job you throw at it. The subscription model has caused division among users, however, although the torrent of updates and new versions that subscribers receive has soothed this somewhat. Elements ($80) comes with its own organizing program—the Organizer—that replicates some Lightroom functions, but falls down on raw image processing and more exotic pro tools. It's a great choice for the enthusiastic amateur, however. Affinity Photo ($50) doesn't try to organize your image files, concentrating instead on pure editing, and striking out from the crowd with its system of Personas that reconfigure the app for specific tasks. We like Affinity, and Photoshop CC is the choice of the professional, but for everyday image manipulation tasks, Elements takes the prize here. ⏻

DOCTOR

THIS MONTH THE DOCTOR TACKLES...

> Speed Boosts
> Upgrade Quandaries
> Perished PSU

Mobile Speed

Hi, Doc. I have a Core i5-2540M, with 6GB of LPDDR3, and a GeForce GT 520M graphics adapter. They're so slow, though! I use Gigabyte's OC Guru and MSI's Afterburner software, so can I crank that hardware up to run even faster? **–Computer Bro**

THE DOCTOR RESPONDS: At the end of the day, you're working with a more than six-year-old mainstream CPU and a GPU with just 48 CUDA cores. No matter how aggressively either is tuned, the absolute impact in today's games will be minimal.

Moreover, there's a good chance that the chassis designed to handle such a combination wouldn't be forgiving of increased heat output. And because mobile CPU and GPU coolers are often linked, adjusting one component may affect the other. Trying to tune both could trigger thermal throttling at the point where you wanted higher performance. So, while it may be possible to overclock what the Doc presumes is a laptop, using a combination of SetFSB and ThrottleStop, your potential upside is limited.

The Doc does understand your plight. After all, he got his start modding a 7.16MHz Tandy 1000 back when his friends were all getting 486-based PCs for Christmas. If you'd like to improve your system's responsiveness, you'll get much more mileage from an inexpensive SSD. That should make the machine a bit faster.

To Upgrade or Not

I bought my PC seven years ago. Although that's eons in the tech world, my Alienware Aurora R3 still holds up well against many of today's mainstream configurations. Admittedly, I have upgraded a number of components, adding a 2TB Samsung 850 EVO SSD, four 8GB Kingston HyperX DDR3-1866 memory modules, and a GeForce GTX 970 4GB video card.

But I'd like to go faster (again). This machine has had its quirks. Over the past couple of years, I've experienced a number of boot problems. Sometimes it goes to the boot screen and stays there, requiring shutdown and a restart. Other times it stops dead while loading Win 10. Sometimes it gets confused as to which drive to boot from, looking to my D:\ drive rather than C:\. Jump online, and you'll find plenty of Dell users having issues with these machines, and most of the issues got worse after Windows 10 launched.

Should I replace the motherboard, processor, and power supply, which I suspect will cure the boot issue, then upgrade the RAM and graphics card again, or buy something totally new? To give you an idea of what I was looking at, the Alienware Area-51 I specced out was just shy of $6,000. That's a lot, but if it serves me for another seven or eight years, the cost seems more reasonable. Most of my use centers around photo processing, gaming, and browsing the Internet. I also recently added an Oculus Rift. So, what would you do? **–Tom Struckman**

Intel's Core i7-7700K is better for gaming than an older 5820K.

THE DOCTOR RESPONDS: The Aurora R3 was a good-looking system during the golden age of Intel's Sandy Bridge. That mostly plastic chassis isn't for everyone, but Alienware's Area-51, in the Doc's opinion, is even more polarizing. Then again, if you dig it, the Doc won't try convincing you otherwise. Let's instead turn to practicality and value—two words seldom associated with flagship PCs.

By the time you swap out your motherboard, CPU, memory, power supply, and graphics card, you've replaced everything except for storage. At that point, it only seems right to add a big PCIe-based SSD for your games, and a hard drive for those photo projects. So, you're basically talking about a complete rebuild inside of the old case versus an entirely new system priced close to $6,000.

An Area-51 up in that range would have a Core i7-6950X, a GeForce GTX 1080 Ti, 64GB of RAM, and a 512GB SATA-based SSD, with 8TB of magnetic storage spinning at 5,400rpm, right? If you're gaming, though, a quad-core Core i7-7700K is arguably smarter (even years down the road, thanks to its much higher clock rate). Drop that into an Aurora with the same 64GB of memory and GeForce GTX 1080 Ti, a better 1TB PCIe SSD, and a 2TB 7200 RPM disk, all for around $3,500. Spend some of the

↘ submit your questions to: doctor@maximumpc.com difference on a G-Sync-enabled 4K display, and you'll still come out way ahead.

A Fork in the Road

Hey Doctor, You helped me in the past, and now I come to you again looking for guidance.

I have an MSI Z97 Gaming 5 motherboard with bad memory slots. I was running two 8GB DDR3-1600 modules for a long time, and am now limited to a maximum of 4GB from one stick if I want the system to POST.

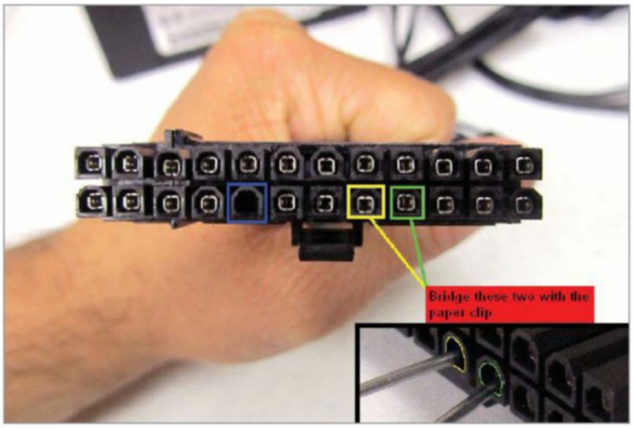
The rest of the PC includes a Core i7-4790K and GeForce GTX 1080 Founders Edition. I have a fallback machine with a Core i7-2600 that I plugged my RAM and graphics card into, and it's working well enough. However, I do experience a lot of in-game lag that I never encountered on the 4790K. I didn't think a slightly older CPU would cause this issue, but it seems like a logical place to start.

As far as I can tell, I'm down to two options: buy another Z97-based motherboard, even though they seem to be rather pricey right now, or shell out the cash for a Core i7-5820K, which I've been eyeballing for a year now.

Neither is particularly attractive, seeing as I'm about to dump some major cash into parts. But I'm not in love with the 2600's performance enough to stay with it. Do you have any advice on which way I should go? **–Brad**

THE DOCTOR RESPONDS: The Doc would also be surprised if your Sandy Bridge-era 2600 inhibits game performance noticeably compared to a Haswell-based 4790K. Have you checked the temperature of your older Core i7 under load? Might it be suffering under old/dry thermal paste, resulting in throttling? How do the two PCs' storage subsystems differ? Does the new one benefit from an SSD, while the old one sputters behind a mechanical disk? Have you logged CPU utilization in games to try correlating the hiccups you're experiencing? There are many variables here, and if you're seriously not looking to upgrade right now, consider focusing energy on troubleshooting. After all, the 2600 is still a solid CPU.

If an upgrade is still in the cards, the Doc suggests a Core i7-7700K/Z270-based mobo combo, landing in between the cost of your two options. Why not buy a new Z97-based board? Well, you could. In fact, if you hadn't mentioned the 5820K, the Doc would probably have suggested as much. So, what about the 5820K? If gaming is your top priority, a six-core chip operating at up to 3.6GHz offers little real-world advantage over Kaby Lake. Extra PCIe connectivity used to be a plus, but multi-GPU configurations aren't as common these days, obviating the need for lots of extra lanes. The old 5820K still sells for more than $400, and compatible motherboards command a premium.



It's not a particularly high-tech solution, but a simple paperclip can help determine whether a PSU is, in fact, deceased.

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Performance Sabotage

Hello Doc. In a long-gone *Maximum PC* forum thread, certain policies at Intel and AMD (maybe Nvidia, too) were discussed. It was believed that performance could be artificially limited by a graphics card's BIOS if someone paired an AMD CPU with an Nvidia GPU. The same choke point would exist with an Intel CPU and AMD GPU. This was acknowledged to exist. Meanwhile, no such bottleneck existed on an AMD/AMD or Intel/Nvidia match.

Does this issue still exist, or has evolution caused it to fade away? Hopefully, you're able to find in your archives where this was covered. I also hope I'm describing the situation accurately; it was a long time ago, admittedly. **–Ron Russell**

THE DOCTOR RESPONDS: Over the years, both AMD and Nvidia have been caught cheating in certain benchmarks to improve their position against the competition. Sometimes the "optimizations" involved not rendering parts of a scene, and sometimes the companies took subtle quality shortcuts. The Doc has even seen developers deliberately add unnecessarily taxing workloads to games that penalize one company more than another.

At other times, AMD and Nvidia were more or less sensitive to platform performance by virtue of their respective architectures, prevalent APIs, and multithreading. For instance, Nvidia's drivers are well optimized for DirectX 11-based games, and you'll commonly see GeForce cards leading comparably priced Radeons in benchmarks. Meanwhile, AMD's highly parallelized GCN architecture excels under DirectX 12, often allowing those same Radeons to jump ahead.

Back to your original question, though. As far as the Doc knows, there was never a deliberate throttle added to AMD/ATI graphics cards to hurt performance on Intel-based platforms, or on Nvidia cards to slow them down on AMD-based PCs. Such a move would only serve to hurt performance in an important market segment.

Dead PSU?

Hi, Doc. I have a custom rig I built a few years ago. One night, I decided to fire it up, and nothing happened. I guessed the PSU was dead, and to be sure I removed it from the system and tried to plug it into another outlet. Same thing. Is it safe to assume that the power supply is, in fact, gone? **–Stu Parker**

THE DOCTOR RESPONDS: When in doubt, try the old paperclip test. Disconnect your power supply from all of your other hardware, make sure it's unplugged from the wall, and flip its switch to the off position. Hook up a case fan in case your PSU requires some load attached before it'll turn on.

Next, bend a paperclip into a U shape. Grab ahold of the 24-pin ATX power cable and locate the green wire (there should only be one). Insert one end of the clip into the connector corresponding to that green wire, and the other end into any of the black (or ground) wire connectors. Set the cable down, plug the power supply back in, and flip its switch back to standby. If your PSU is still good, its fan and the case fan should start spinning. ⏻

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CORSAIR® 16GB DDR4 2400Mhz Dual Ch. Memory
240GB SSD + 2TB SATA-III 3.0 HDD 7200 RPM
NVIDIA® GeForce® GTX 1060 3GB Video Card
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REINSTALL & REINVIGORATE WINDOWS

Make your next Windows reinstall a better experience with *Nick Peers*

MusicBee
Sizer
TidyTabs
WinSnap
xvid4psp
File and Backup
Bulk Rename Utility
CloneApp
DMDE (Disk Editor and Data Recove
Recuva
SpaceSniffer
Games
SteamMover
Graphics and Pictures
IcoFX
PortableFotoSketcher_3.20_x64
XnConvert Application
XnView
Internet
FileZilla
Documents
Music
Pictures
Videos
Explore
Backup
Apps
Options
Search
Help
PortableApps.com
Drive (D:) 20.6GB free of 69.8GB
15:06

It had been two years since our previous Windows reinstall when we came to write this piece. That's normally a reasonable time to wait between wiping your hard drive clean and starting again, although given the size of our Windows install (90GB and rising), it was clear that we'd possibly waited too long. Despite 16GB of RAM, a fast SSD boot drive, and quad-core processor, Windows took what felt like an age to get going after booting, while there was a noticeable slowdown in performance.

Unsurprising, really: Since we last wiped the drive, we'd installed two major Windows 10 updates—the Anniversary Edition and the Creators Update. It was obviously time for a complete overhaul, but bitter experience had taught us a few lessons along the way. Some of those lessons go back to the early days of Windows; others are peculiar to Windows 10.

And that's where this feature comes in. We're going to take you on the ultimate Windows reinstall tour, whether you're installing Windows 7, 8.1, or 10. You'll discover that the actual physical act of reinstalling is the simplest bit, so we'll step you through everything you need to do to preserve your data, transfer settings across the reinstall divide, and ensure nothing gets left behind—just in case.

We'll show you how to prep for reinstall by bringing all your key apps, drivers, and licenses into one place (oh, and don't forget to uninstall apps that need deactivating prior to reinstalling). You'll discover how to source the latest version of your Windows install media for a cleaner, more up-to-date install out of the box (we'll also reveal a tool that gives you the power to craft your ultimate reinstall disc).

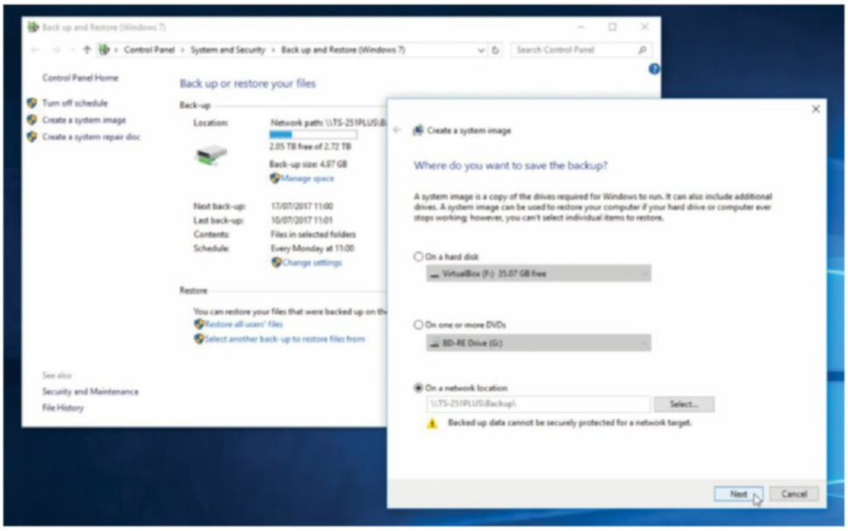
We'll step you through the install process, but crucially, we'll be on hand to guide you through the post-setup phase: Get Windows up and running again, reinstall core apps, restore links to your data folders, bring back your app settings, and—for good measure—install a snapshotting backup regimen that lets you roll back your PC quickly when the need arises. Long story short, everything you need is here. Enough preamble—let's reinstall Windows!

BEFORE YOU START

Step one of the reinstall process is to make sure you're fully backed up. Let's begin by taking a fail-safe drive image of your computer in its current state. Not only does this give you something to roll back to if the reinstall process fails for any reason, but it also ensures that every scrap of your current configuration—including programs and their settings—are accessible in case you need to refer to or access them after performing the install.

There are plenty of good third-party drive-imaging tools out there, but for the purposes of your fail-safe image, let's stick with the Windows 7 Backup and Restore tool. The quickest way to launch it in any version of Windows—including Windows 10—is to press Win-R to open the "Run" dialog, then type "sdclt.exe" and hit Enter. Click "Create a system image," choose your backup drive as the destination, and click "Next." By default, your system partitions should be selected, so verify there's enough space on your target drive (the actual backup will be smaller than the size indicated), and click "Next" again.

With your fail-safe backup in place, it's time to turn your attention to your data. If you've been diligently backing up using File History or the Windows Backup and Restore tool, you should be covered, although if you're using the latter, open it, and click "Back up now" to ensure it's fully up to date.



Back up and Restore (Windows 7)
Control Panel > System and Security > Back up and Restore (Windows 7)
Search Control Panel
Control Panel Home
Turn off schedule
Create a system image
Create a system repair disc
See also
Security and Maintenance
File History

Back up or restore your files

Back-up

Location: Network path: \\TS-251PLUS\B

2.05 TB free of 2.72 TB

Back-up size: 4.97 GB

Manage space

Next back-up: 17/07/2017 11:00

Last back-up: 10/07/2017 11:01

Contents: Files in selected folders

Schedule: Every Monday at 11:00

Change settings

Restore

You can restore your files that were backed up on th

Restore all users' files

Select another back-up to restore files from

Create a system image

Where do you want to save the backup?

A system image is a copy of the drives required for Windows to run. It can also include additional drives. A system image can be used to restore your computer if your hard drive or computer ever stops working; however, you can't select individual items to restore.

○ On a hard disk: VirtualBox (F:) 35.07 GB free

○ On one or more DVDs: BD-RE Drive (G:)

● On a network location: \\TS-251PLUS\Backup\ Select...

Backed up data cannot be securely protected for a network target.

Next Cancel

Take a fail-safe backup image before you begin.

Another option is to move your data to a different drive or partition, so it's left untouched when you reinstall Windows. You need to fix permissions after reinstalling, but we'll cover that in due course. If you don't have a second hard drive available (make sure it's not your backup drive), check out the boxout below for details of partitioning your system drive in two. Once set up, create a user folder on the root of your new drive or partition, then open File Explorer, and start moving user folders over to the new drive by right-clicking each in turn, and choosing "Properties → Location tab." Click "Move" to select the corresponding folder on your data drive, then choose "Yes" when prompted, and all your files are moved to the new drive. If you've got cloud folders hosted on your system drive, don't forget to move them now, too, to save the bother of a lengthy resync post-install. In this case, copy rather than move the files—you can link your cloud sync app to the correct folder after reinstallation.

BACK UP PROGRAM SETTINGS

This is a key part of the reinstall process. If you want to avoid having to meticulously record all of your program settings, the best thing to do is find ways

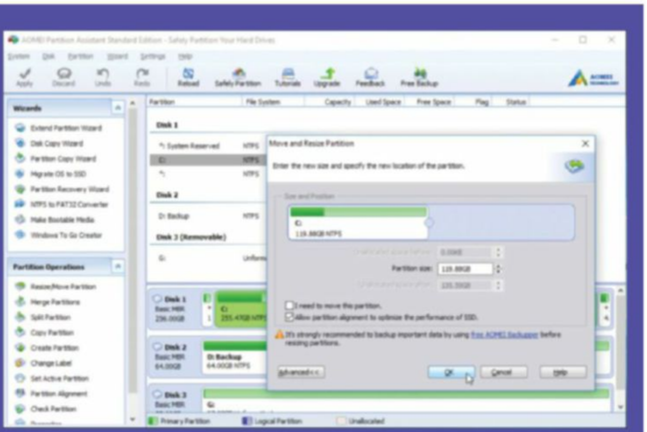
PARTITION YOUR DRIVE

You need a secondary (not backup) drive if you want to separate data from Windows. If you don't have one, you can partition your main drive in two to split Windows and your apps from your documents, photos, portable apps, and any files not directly tied into Windows.

It is possible to partition using the Disk Management tool (type "diskmgmt.msc" into the "Run" dialog box), but if files are situated at the end of the drive, you won't be able to partition it to the size you want. Instead, download and install AOMEI Partition Assistant (www.aomeitech.com/aomei-partition-assistant.html).

Ascertain how you wish to split your drive in two—typically look to allocate 64GB or more for your Windows partition, depending on the number of apps and games you use, leaving the rest for your data. If space is currently at a premium, temporarily move your data off the drive while you create the second partition.

Launch Partition Assistant, select your Windows drive (typically drive C), and click "Check Partition." Choose "Scan and Repair," and reboot to let it do its work. Once complete, restart Partition Assistant, select drive C again, and this time choose "Resize/Move Partition." Use the slider to shrink the drive by the amount you wish to free up for your data partition. Be sure to leave at



AOMEI Partition Assistant Standard Edition - Safely Partition Your Hard Drives
Move and Resize Partition
Partition size:
Advanced
OK
Cancel
Help

least 5GB (preferably more) of free space for your system drive. If partitioning an SSD drive, click "Advanced," and select "Allow partition alignment." Click "OK."

Next, select the unused space, and click "Create Partition." Leave all available space allocated, and "File System" set to "NTFS." Click "Advanced" to set a label (such as "Data"), but leave all other settings alone. Click "OK," then "Apply." Review the changes, then click "Proceed." Reboot when prompted—when done, your new drive shows up in Windows, ready for your data.

of backing them up. Start by downloading the free portable tool CloneApp from www.mirinsoft.com (go to "Download Resources → CloneApp—Portable"). Right-click "cloneapp.zip," and choose "Extract All"—save it to your backup drive (or portable apps folder if you have one), then open the CloneApp folder, right-click "CloneApp.exe," and choose "Run as administrator."

A list of supported apps is displayed. Click "Select Installed," and CloneApp automatically selects all the applications in its database that you've installed—including some handy Windows settings, such as Library and network settings. Go through the list, unchecking those you have no plans to restore along with Windows.

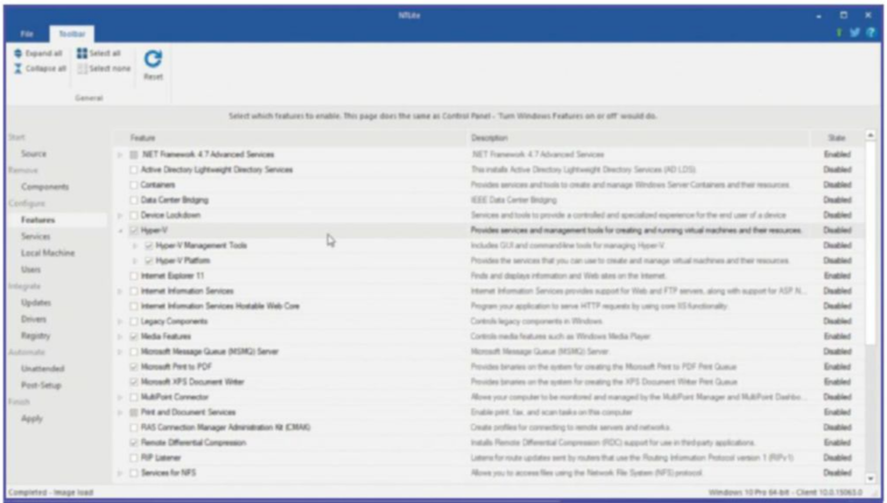
To see what's being backed up, click "What is being backed up," and a complete list of apps and their settings (such as Registry entries or associated folders) is shown. If you click "Start CloneApp," these settings and files are backed up. Simply uncheck an item to exclude it from the backup, then click "Update."

Not all your programs will be supported here, but you can still back up their settings using CloneApp if you can identify where they're stored—either in the Registry or in a specific folder. Start your search under the C:\User\<username>\AppData and C:\ProgramData folders, as well as the app's own folder under C:\Program Files or C:\Program Files (x86). Also open the Registry Editor (type "regedit" into the "Run" dialog), and look under the HKEY_CURRENT_USER\SOFTWARE Registry key for any subkeys related to your apps.

Once you've identified where they are, click the "Custom" button in CloneApp, and click the appropriate buttons ("Files," "Folders," or "Registry Keys") to manually add these locations. If you're struggling to locate them, try Googling the program name, along with words such as "backup" and "settings," or explore the app's own preferences or settings for an option to "export settings" to back them up manually.

Another important consideration is your saved games—try the free GameSave Manager tool from www.gamesave-manager.com, where you'll find its database supports over 4,750 games.

Now might also be the time to consider migrating to portable apps where you can—these can be stored on your data drive, and will survive all reinstalls with their settings intact. Use the PortableApps.com platform tool to manage and launch them—you can download and install apps from here, or manually add them to the PortableApps folder inside their own folder. Then open the PortableApps.com platform, and click "Apps → Refresh App Icons" to bring them into the program menu.



THE ULTIMATE REINSTALL DISC

If you want full control, it's possible to create the ultimate customized install media. But be warned: It's for technical users only.

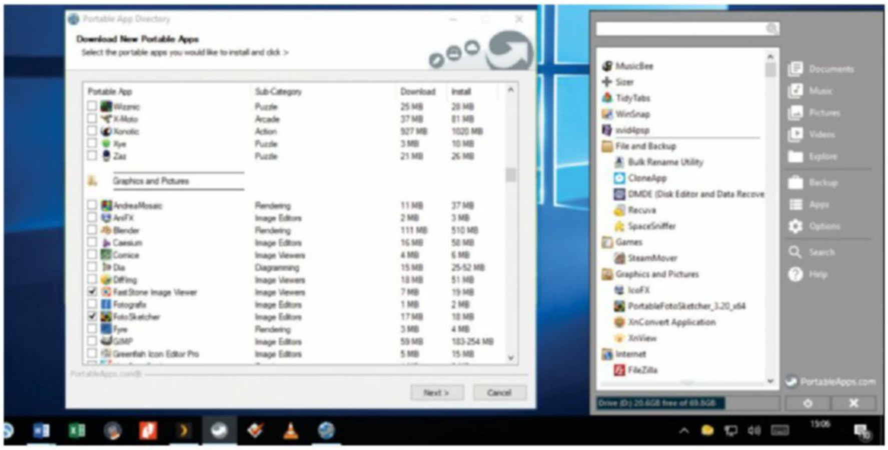
Download and install the free version of NTLite from www.ntlite.com. Once set up, launch the app. The simplest way to use it is in conjunction with a previously created installation flash drive—with that plugged in, click "Add" to select the drive containing your Windows install files. The OS appears in the list—click it to mount it.

Once the source has been added, several options appear down the left-hand side of the NTLite window. Start with "Components"—read the warning (it's a good idea to test your customized Windows install in a virtual environment, such as VirtualBox, as advised), and click "OK." From here, you can remove various components—including drivers, selected apps, and localization files—to slim down the size of your install media and subsequent Windows install. You'll see some options are marked in blue and grayed out—you need to pay for a full license (from $45) to access these.

The "Configure" section enables you to choose which elements are pre-installed, and which ones need to be manually enabled after installation—you can disable Internet Explorer 11 and Windows Media Player, and enable Hyper-V support out of the box, for example.

Go to "Integrate" to slipstream Windows Updates and Drivers into the media—these will be automatically installed after Windows, so while lengthening the overall install time, it saves you the hassle of doing so manually. Finally, the "Automate" section enables you to skip some of the setup questions.

Once done, apply your changes, then—if necessary—generate a new ISO file, which you can burn to disc or copy to USB flash drive using a tool such as Rufus (https://rufus.akeo.ie).



If you switch to portable apps, you save time configuring them.

MORE REINSTALL PREP

Before going further, make sure you have the program media you need—install CDs and DVDs, plus any product keys. If you purchased digitally, simply make sure you have access to your online account, or check your email for the keys you need. If you're struggling to track down product keys, a free portable tool such as License Crawler (www.klinzmann.name—use the "Mirror ServeSr (1)" link on the "Download" page) can track down the information you need.

Go through your list of programs for those that require activation—some, such as Nitro Pro, need to be deactivated or uninstalled before you reinstall Windows. Scour the Taskbar and Taskbar Notification area, as well as the Start menu, for apps you may have forgotten about.

Also consider your drivers. Driver backup tools are available, but a neater solution is to source your own core drivers now if required. Most drivers can be reinstalled after Windows—many even come as part of Windows—but it's important you can verify specific drivers are covered. These include your display drivers—particularly for older AMD cards—as well as network drivers, enabling you to get back online.

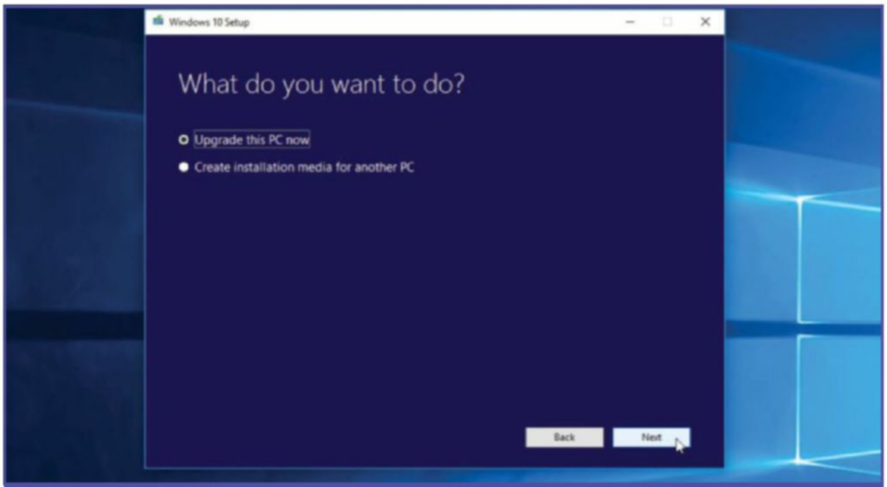
If Windows was pre-installed on your PC, don't assume your drivers are guaranteed to come back when you reinstall. Instead, visit your PC manufacturer's website now to source drivers for the version of Windows you plan to install. You should find most here—if your PC is self-built, the motherboard manufacturer's website is a rich source of drivers, too.

If you can't find supported drivers for your version of Windows, drivers for an older version—such as Windows 7 for Windows 10—may still work if required, so long as they're the same system type (32-bit or 64-bit) as your version of Windows.

Finally, if you open Device Manager (type "devmgmt.msc" into the "Run" dialog), you can see what drivers are installed for your hardware—double-click an item and switch to the "Driver" tab. If the Digital Signer states "Microsoft Windows Hardware Compatibility Publisher," it's likely that the driver will be installed with Windows; if the provider is Microsoft, it's a given.

BUILD YOUR REINSTALL MEDIA

Time to reinstall, right? Wrong. You may already have a Windows install CD—particularly if you're rolling back to an earlier version of Windows—but it



Windows 10 Setup

What do you want to do?

○ Upgrade this PC now

● Create installation media for another PC

REPAIR, NOT REINSTALL

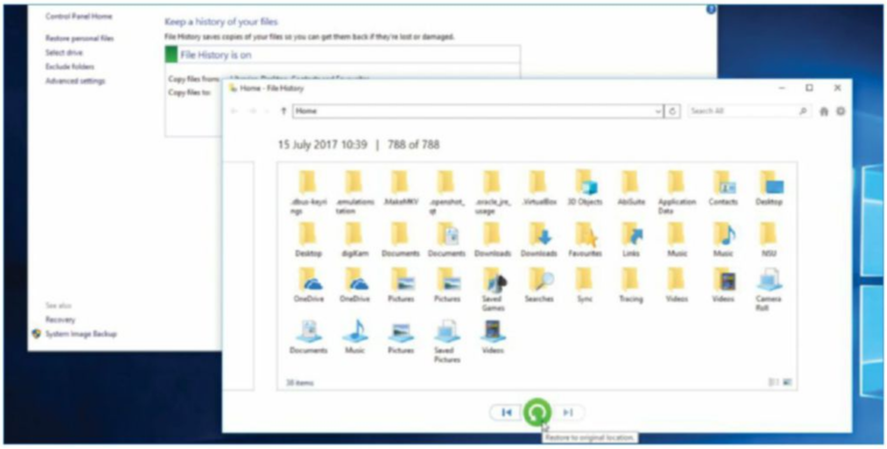
Reinstalling Windows is often seen as the ultimate solution to any problem. If you're reinstalling to fix problems, rather than clear out a clogged up system, once you've ascertained it's an issue with Windows, rather than a hardware problem, ask yourself whether a full-blown Windows install is required. If your PC is functioning perfectly other than some specific glitches—Microsoft Edge no longer works after the Creators Update, for instance—a repair install may be a better option.

Repair installs simply overwrite Windows files—your apps, programs (including their settings), and any data on your system drive is theoretically left untouched. The procedure for performing a repair install varies between each version of Windows, but they share one common characteristic: You have to be able to boot into Windows to launch the repair from the Windows desktop.

Windows 7 and 10 users can insert their Windows install media and launch the installation process from there. When prompted, choose the "Custom" option to "upgrade" your existing installation. If your Windows 10 media isn't the latest version, run the Media Creation Tool instead, and choose the "Upgrade" option from there—make sure you select the option to keep personal files and apps before clicking "Install."

Windows 8.1 provides a handy "refresh" option, which enables you to reinstall Windows over the top of itself—access this from "Change PC settings → Update and recovery → Recovery," then click "Get started" under "Refresh."

The installation process is identical to performing a full reinstall, but at the end of it, your programs and data are untouched; only Windows gets refreshed, hopefully resolving whatever problems you've been having. Note: It's a lengthy process, so be prepared to wait an hour or more, depending on the speed and state of your PC.



Keep a history of your files

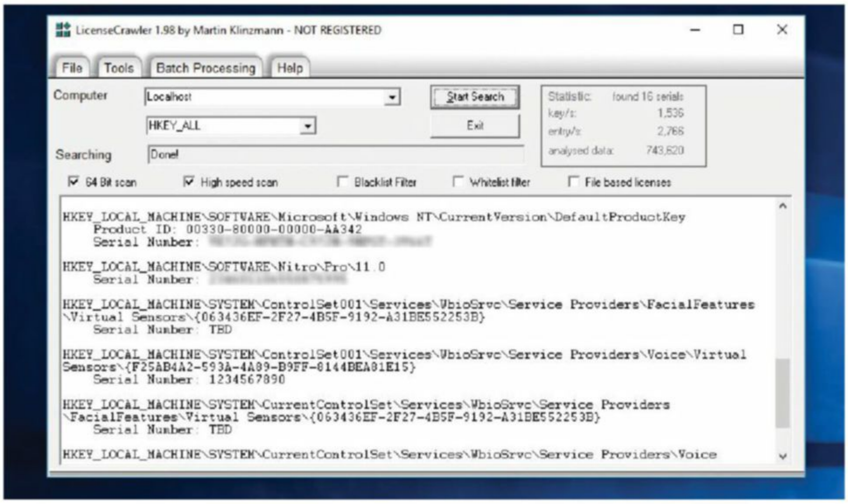
File History saves copies of your files so you can get them back if they're lost or damaged.

File History is on

15 July 2017 10:39 | 788 of 788

Control Panel Home
Restore personal files
Select drive
Exclude folders
Advanced settings
Copy files from:
Copy files to:
Home - File History
Home
Search All
.dbus-keyrings
.emulationstation
.MakeMKV
.openshot_qt
.oracle_jre_usage
.VirtualBox
3D Objects
AbiSuite
Application Data
Contacts
Desktop
Desktop
digiKam
Documents
Documents
Downloads
Downloads
Favourites
Links
Music
Music
NSU
OneDrive
OneDrive
Pictures
Pictures
Saved Games
Searches
Sync
Tracing
Videos
Videos
Camera Roll
Documents
Music
Pictures
Saved Pictures
Videos
30 items
See also
Recovery
System Image Backup
Restore to original location

Don't forget to restore your file backup post-reinstall.



Computer: Localhost
HKEY_ALL
Searching: Done!
Statistic: found 16 serials
key/s: 1,536
entry/s: 2,766
analysed data: 743,620
☑ 64 Bit scan ☑ High speed scan ☐ Blacklist Filter ☐ Whitelist filter ☐ File based licenses

```
HKEY_LOCAL_MACHINE\SOFTWARE\Microsoft\Windows NT\CurrentVersion\DefaultProductKey
    Product ID: 00330-80000-00000-AA342
    Serial Number: [redacted]

HKEY_LOCAL_MACHINE\SOFTWARE\Nitro\Pro\11.0
    Serial Number: [redacted]

HKEY_LOCAL_MACHINE\SYSTEM\ControlSet001\Services\WbioSrvc\Service Providers\FacialFeatures
\Virtual Sensors\{063436EF-2F27-4B5F-9192-A31BE552253B}
    Serial Number: TBD

HKEY_LOCAL_MACHINE\SYSTEM\ControlSet001\Services\WbioSrvc\Service Providers\Voice\Virtual
Sensors\{F25AB4A2-593A-4A89-B9FF-8144BEA81E15}
    Serial Number: 1234567890

HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Services\WbioSrvc\Service Providers
\FacialFeatures\Virtual Sensors\{063436EF-2F27-4B5F-9192-A31BE552253B}
    Serial Number: TBD

HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Services\WbioSrvc\Service Providers\Voice
```

Make sure you note down your product keys and licenses.

may not be the latest version. Why force yourself to install more Windows Updates than necessary—the Creators Update for Windows 10, or Service Pack 1 for Windows 7, for example—when you can download and create the latest version of your Windows install media, which comes with these updates pre-installed? Not only do you save yourself time, but you ensure your install is as clean as possible.

You need one of two things for your install media: either a blank DVD (or possibly two) or a large enough USB flash drive (typically 8GB or larger). The latter is preferable, because installing from this is much quicker than via DVD, but verify your PC can boot from USB drives before proceeding—any PC worth its salt from the last decade should be able to, but check with the manufacturer before proceeding.

If you'd like to craft the ultimate reinstall disc—complete with more slipstreamed updates and Windows configured just so—check out the box on NTLite (pg. 29).

Win 7 users who want to create reinstall media with Service Pack 1 slipstreamed into it should head to www.microsoft.com/software-download/windows7—you need to provide your Windows product key, and you're pointed toward one of two ISO downloads for 32-bit and 64-bit. Unless your PC is incredibly old, 64-bit is the preferred choice. It allows you to use more than 4GB of RAM, and offers better performance.

One key consideration may be older hardware—check you can source 64-bit drivers, or you may have to replace the hardware or stick with the 32-bit version.

Once the ISO file is downloaded, grab the Windows USB/DVD Download Tool from https://wudt.codeplex.com—this enables you to create your Windows 7 install media from the ISO file.

Things are simpler if you want to reinstall Windows 8.1—go to www.microsoft.com/software-download/windows8—or Win 10 (www.microsoft.com/software-download/windows10). Both versions of the Media Creation Tool enable you to download the latest version of the installer files—the Creators Update for Win 10—then burn a DVD or create a bootable USB flash drive.

TIME TO REINSTALL

It's time to ditch your underperforming, glitchy Windows for a brand new install. You're all backed up, your data has been moved to a new partition or drive, and you've sourced any key drivers you might need.

First, insert the install media and restart your PC. If it's set to look for a bootable DVD or USB drive, you see a message inviting you to press any key to boot from CD or DVD—press it and jump to the next paragraph. If not, look for a message inviting you to enter the boot menu. When the menu appears, select your DVD drive or USB flash drive from the list, and hit Enter; if two entries exist, try the one marked "UEFI" first.

Win 8 and 10 users may find no options appear on startup—this is down to your PC's

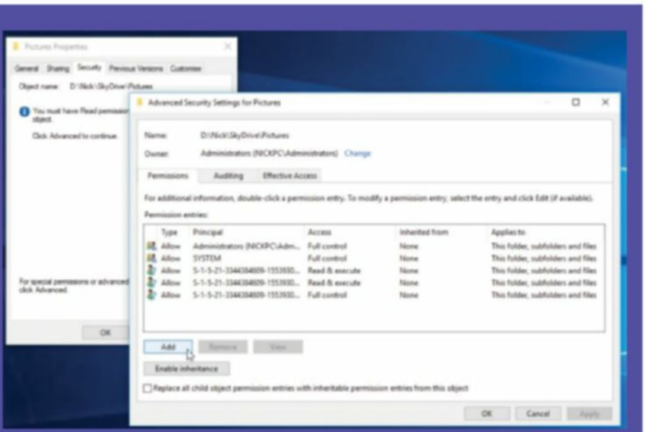
FIX PERMISSIONS

When you hive off your data to a separate partition or drive, you may have issues accessing your user folders after reinstalling Windows. That's because they're "owned" by your current user account, and when you reinstall Windows, you end up creating a new user account, even if it's identical to your old one.

In most cases, when you first try to access one of these folders—when you point Windows toward them, say—you're told access is denied, but are prompted to click "Continue" to gain permanent access.

This usually resolves the issue, adding your current user account to the list of users permitted access. If it fails, you need to manually take control of the folder. Right-click it, and choose "Properties → Security tab." If there aren't any read permissions, click "Advanced," followed by "Continue." Next, click "Add," followed by "Select a principal," then click "Advanced → Find Now."

You have a choice—if you share your PC with others, select your username; if you're the only user, you could select "Everyone," which saves the hassle of having to repeat this process every time you reinstall Windows (though if it's a laptop, ask yourself if you want the data accessible to anyone who might steal it). Click "OK" twice, and you should now be able to assign basic permissions—choose "Full Control" if you were the previous owner of the folder. Click "OK," select "Replace all child objects," and click "Apply → OK." Click "OK" twice, and you should now have access. If you're feeling zealous, right-click the folder again, and choose "Properties → Security tab." Click "Edit," then select each "Account unknown" entry (a reference to earlier Windows installations), and click "Remove" followed by "OK" to get rid of them all.



Object name: D:\Nick\SkyDrive\Pictures
You must have Read permissions to view the properties of this object.
Click Advanced to continue.
For special permissions or advanced settings, click Advanced.

Name: D:\Nick\SkyDrive\Pictures
Owner: Administrators (NICKPC\Administrators) Change

For additional information, double-click a permission entry. To modify a permission entry, select the entry and click Edit (if available).

Permission entries:

Type	Principal	Access	Inherited from	Applies to
Allow	Administrators (NICKPC\Adm...	Full control	None	This folder, subfolders and files
Allow	SYSTEM	Full control	None	This folder, subfolders and files
Allow	S-1-5-21-3344384609-1553930...	Read & execute	None	This folder, subfolders and files
Allow	S-1-5-21-3344384609-1553930...	Read & execute	None	This folder, subfolders and files
Allow	S-1-5-21-3344384609-1553930...	Full control	None	This folder, subfolders and files

☐ Replace all child object permission entries with inheritable permission entries from this object ultra-fast boot setting. If this is the case, boot back into Windows, then navigate to "Start → Settings → Update & security → Recovery," and click "Restart now." When the advanced startup menu appears, click "Use a Device" to select your boot device.

If you're downgrading from Win 8 or 10 to Win 7, you need to tweak some UEFI settings—from the advanced startup menu, choose "Troubleshoot → Advanced → UEFI Firmware Settings." Now look for the "Fast Boot" and "Secure Boot" settings, disabling both. If there's a "CSM (Compatibility Support Module)" setting, make sure it's enabled. Once done, save your settings and exit, then start the reinstall process.

INSTALLATION STEP-BY-STEP

The basic install process is practically identical across Windows 7, 8.1, and 10. When the Windows Setup wizard starts, verify that the language, time, and currency, and keyboard are all set to your chosen language. Click "Next," followed by "Install Now." At this point, Windows 8.1 and 10 users are prompted for their product key; Windows 10 users can skip this step if they upgraded to Windows 10 from Windows 7 or 8.1, because your license is digital and tied to your computer; Windows activates automatically after installation.

If prompted to choose a Windows edition, select the one you're currently running—typically Home. Click "Next," agree to the license agreement, and click "Next" again. Now select "Custom: Install Windows only (advanced)" by clicking it.

A list of available drives appears—your current Windows partition should be selected by default, but check that the size, type (Primary), and free space match what you expect. Click "Format" to wipe the drive, then click "OK" to confirm the warning. With the drive selected, click "Next."

There are two distinct phases to the installation process. First, files are copied and prepared for installation. Then Windows starts installing features and updates. It then informs you it needs to restart—this happens automatically, or you can click "Restart Now."

If prompted to boot from CD or DVD, don't press anything. You'll see the Windows logo appear for the first time, then a series of messages about preparing devices and getting ready pop up. Windows may restart several times.

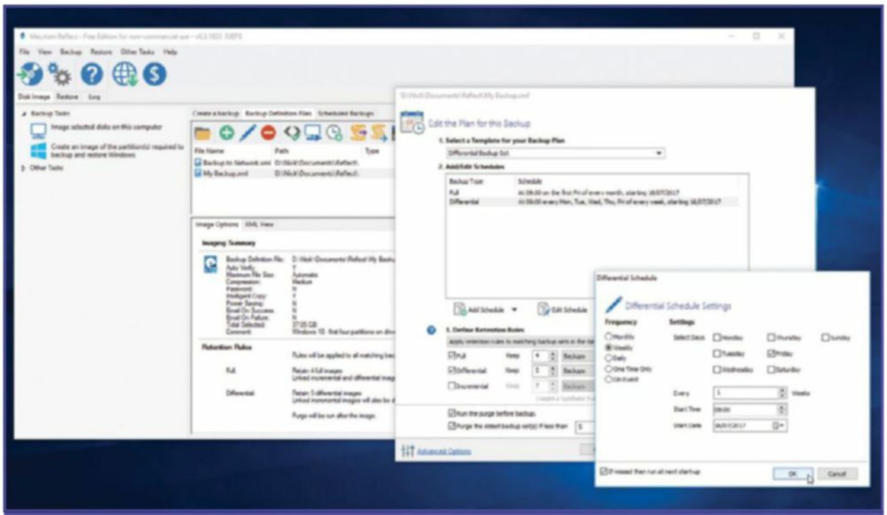
SET UP WINDOWS

This stage of the process is simple enough for Windows 7 users: Enter your product key when prompted, and follow the prompts to set up a user account, and get going. The same is true for Windows 8.1, although its "Express Settings" option isn't as pervasive as Windows 10.

Windows 10 first asks you about your location and keyboard, sorts out your network connection (including any Wi-Fi configuration), then asks you whether you're setting up for personal use or for an organization. Personal is the choice for most. You're then prompted to sign in with your Microsoft Account—if you're sticking with an old-school local user account, click "Offline account," followed by "Maybe later."

If signing in, you go through the usual procedure, including any additional verification or authentication you may have set up. You're prompted to set up a PIN, then asked to set up Cortana. This is the point where privacy comes into play, so review all options carefully, flicking the slider to "Off" for any you don't need or use.

That's the end of the setup process—Windows now configures itself based on your choices, and you see a series of messages appear on screen. Eventually, when all is ready, you find yourself back at the familiar Windows 10 desktop.



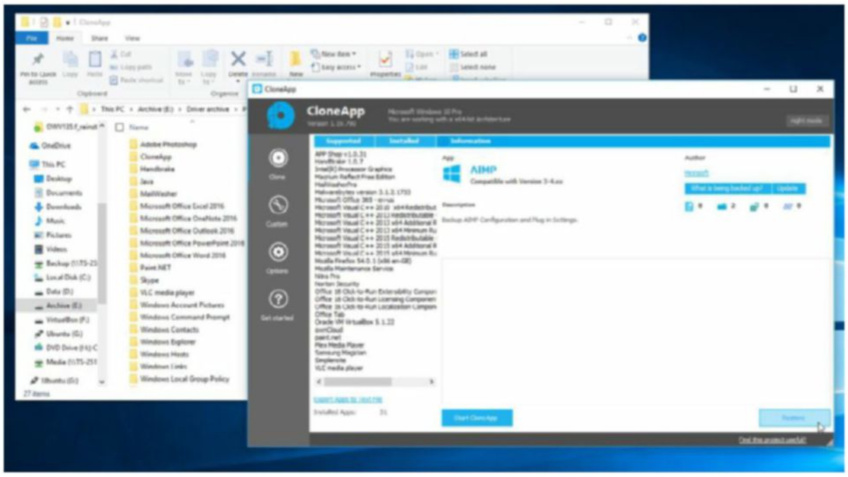
SET UP SNAPSHOTS

The Windows drive-imaging tool is fine for occasional image-based backups, but if you want to regularly back up your entire Windows installation without running out of drive space—handy if you want to test software, then roll things back without making permanent changes to your system, for example—you need a tool that offers differential backup images, such as Macrium Reflect Free (www.macrium.com/reflectfree.aspx). Differential images only record the changes made since the last backup was taken, reducing their file size dramatically.

Once installed (create the rescue media when prompted, in case of disaster), click "Create an image of the partition(s) required to back up and restore Windows." Select a suitable location on your backup drive, and click "Next." Click the "Template" drop-down, and choose "Differential Backup Set" to create a schedule that makes a monthly full drive image, then daily differential images—select "Differential," then "Edit Schedule" to change this (to a weekly schedule, say).

To prevent drive space from running out, tweak the "Define Retention Rules" by weeks, days, or number of backups. Click "Next" to review your settings—click "Advanced Options → Auto Verify Image," and check the box to automatically verify your drive image after it's created. Click "OK," followed by "Finish." You need to enter your account password to enable scheduled backups, and Macrium is set up to back up automatically going forward, but you need to create your first backup: Switch to the "Backup Definition Files" tab, select your backup definition file, and click "Run," choosing "Full" from the drop-down.

If you're diligent, create another backup job from here to periodically back up to an alternative location—a network drive, say—to provide an extra layer of redundancy for your Windows installation.



CloneApp restores all backed-up settings with a click.

POST-INSTALL SETUP

The Windows desktop is back, and you should notice things are much quicker. They won't remain this fast, though—not once you've reinstalled your core apps and settings—but you'll still end up with a much quicker PC once you're done.

Let's start by bringing Windows fully up to date. Windows Update should already be operating in the background, but you can move things along by opening it (via "Settings → Update & security" in Windows 10), and performing a manual scan. Let all updates install themselves, then reboot.

Now is a good point to reinstall any third-party security software you have, then it's time to restore your personal data (or link it back into Windows if you've moved it to another partition or drive). If you've backed it up previously, you need to open File History or Backup and Restore, and choose the "Restore" option. Locate your backup, and choose the option to restore it to its original location.

If you've partitioned your hard drive and hived off your data folders to another drive, open your user folder, and repeat the process for pointing your user folders to their new locations (again, choose "Yes" when prompted to move any existing data—this doesn't affect your data). If you run into permissions issues, see the boxout (pg. 31).

Next, go through Settings and the Control Panel, setting things up as you remember. For example, type "sysdm.cpl" into the "Run" dialog box to set up your Workgroup, rename your PC, switch System Restore on (Windows 10 now disables it by default), and make various other system tweaks. If you have any Windows tweaking apps, such as the Ultimate Windows Tweaker (www.thewindowsclub.com)—which, among other things, enables you to use Windows Photo Viewer as your default image viewing app—now's the time to run them.

One final step for Win 10 users: Download and run the portable O&O ShutUp10 tool from www.oo-software.com/en/shutup10 to tighten Windows' lax privacy controls.

RESTORE PROGRAMS

Now might be a good time to take your first post-install drive image—a nice clean image you can roll back to if your next round of post-setup actions goes awry. See the boxout opposite for an alternative to Windows' own Backup and Restore tool.

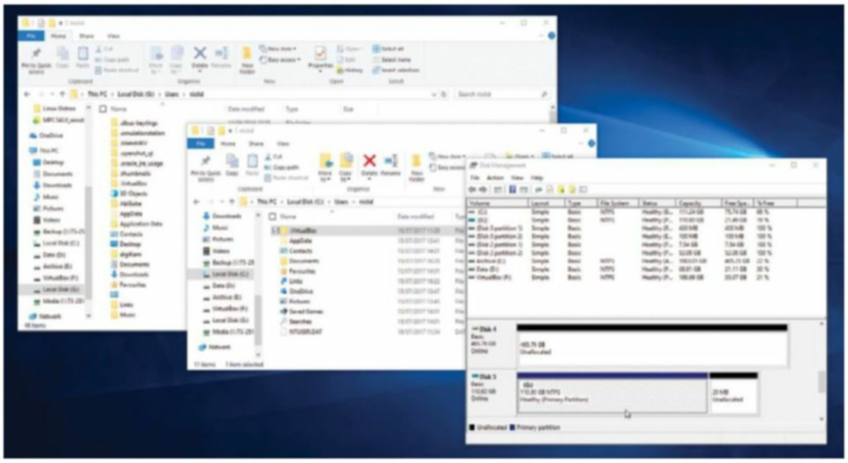
Once done, start reinstalling all your core apps, making sure you run them to reactivate or register any license keys. Once done, run CloneApp from your backup drive. If you click "Restore," every single setting you've backed up is restored; if this doesn't appeal, open the CloneApp\Backup folder, and move out any program folders to exclude them from the process. If prompted to overwrite files when restoring, choose "Yes" to replace new files with your backed-up versions. If all goes well, you should find, when you next open your programs, that they've got your old settings intact.

If you find you've forgotten to back up a file or program setting, what then? This is where your fail-safe drive image comes into play. Step one is mounting the image as a virtual drive in Windows: Type "diskmgmt.msc" into the "Run" dialog, then choose "Action → Attach VHD." Click "Browse," and go to "WindowsImageBackup\<Computer Name>\Date" on your backup drive, where you'll find several VHDX files. Select the largest one, and click "Open → OK." The partition is highlighted, so right-click it, and choose "Change Drive Letter and Paths." Click "Add" to allocate it a drive letter, and you can browse its contents in File Explorer, enabling you to copy off any files you need.

If you need to locate and extract Registry settings from your old installation, open Registry Editor, and select "HKEY_LOCAL_MACHINE" from the list. Then choose "File → Load Hive." You can then browse to the drive you've just mounted, and load the following files from the locations listed, depending on which Registry hive you need (typically HKEY_CURRENT_USER or HKEY_LOCAL MACHINE\SOFTWARE).

HKEY_LOCAL_MACHINE\SAM:
Windows\system32\config\SAM
HKEY_LOCAL_MACHINE\SYSTEM:
Windows\system32\config\SYSTEM
HKEY_LOCAL_MACHINE\SOFTWARE:
Windows\system32\config\SOFTWARE
HKEY_USERS\.Default:
Windows\system32\config\DEFAULT
HKEY_CURRENT_USER:
%userprofile%\ntuser.dat

Browse these keys for missing data, export it to your hard drive as .REG files, then reimport them into the Registry. ⏻



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LIQUID COOLING LIQUIFIED

A deep dive into how to take your PC to the next liquid-cooled level, and whether it's worth it. *By Zak Storey*

Ah, liquid cooling, the high-tech love child of a mad plumber and a computer enthusiast. Once upon a time, we lived in a world where the very thought of mixing water and computing hardware was seen as blasphemous. Fast-forward to 2017, however, and it's now commonplace. AIOs litter the landscape of build guides, high-end systems, and even home theater PCs. There have even been attempts to liquid-cool entire server rooms in the pursuit of more efficient thermal voiding.

Alas, building your own loop still bears the scars of the stigma that plagued the community all those years ago. And despite being easier and safer now than it ever has been, the comments remain the same: It's not safe, it costs too much, I don't want to mess up, what's the point?

And they're exactly the kind of comments we want to address here. With EKWB announcing its latest do-it-yourself, complete, aluminum kits, we just had to take them for a full-on test drive. Hopefully proving, once and for all, that custom liquid cooling isn't just a pursuit for the affluent, but something that anyone who's passionate about their rig can do, too.

To break it down, these new Fluid Gaming Kits are available in three different SKUs: a 120mm CPU version at $150, a 240mm variant at $160, and a 240mm kit with GPU and CPU blocks for $240, the latter of which is compatible with any Nvidia GeForce GTX 1060 series and above GPU, featuring a reference PCB (although a Vega option is on its way). All three kits come with tubing, fans, fittings, coolant, radiators, blocks, and the pump-res combo that you need to build your own liquid cooling system from scratch.

For the price of an NZXT Kraken X62, you can hook yourself up with an efficient expandable loop, capable of dispersing the heat from your precious components. Couple that with the included Vardar fans, and this suddenly becomes a clean, bespoke cooling system, just for you.

So, join us as we debunk some of the oldest and dirtiest myths surrounding the greatest of PC enthusiast pursuits....

BUILD IT!
Step-by-step guide
PG. 70

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CROSSHAIR VI
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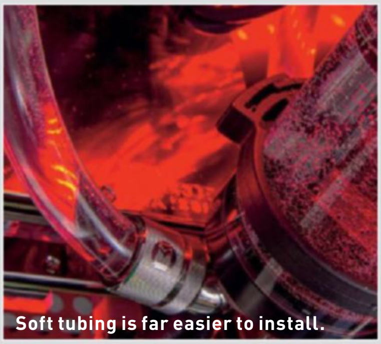
CROSSHAIR VI HERO
AIR

The Types

Hardline cooling is popular and classy.


Soft tubing is far easier to install.

Every liquid-cooled build falls into one of two camps, based around the tubing used. There are two types that the enthusiast community takes advantage of right now: hard tubing and soft. Each has its own advantages and disadvantages. Soft tubing, the most common type, is usually a form of flexible PVC, capable of being cut to length with relative ease. Available in many colors, it's commonly found with an outer diameter of 13, 16, or 19mm, and can be used with a barb, or specially designed compression fittings, which are a combination of a barb, with an o-ring and compression cap on top.

Its successor—which is arguably more difficult to work with—is hard tubing, also known as hardline, an umbrella term for everything from acrylic, to copper, even glass tubes. Often requiring special tools to cut and shape, it's a far more difficult material to manipulate, though it provides cleaner lines and tighter bend radii than its soft-tube counterparts. Acrylic was the first hard tubing used in liquid cooling, thanks to its ability to change shape when heated. It's still available today, and is sometimes preferred to its PETG successor. To shape it, you simply place a silicon insert into the tube, heat evenly along the part you want to bend, and slowly bend it into the angle you require, before cooling it. Over time, it's become quite an art form, with modders creating all sorts of complex and ludicrous angles, styles, and lines. PETG is a more complex polymer, designed to address acrylic's lack of shatter tolerance, and is now one of the most common materials used by the hardline community. Hard tubing traditionally used what's known as push fittings, but today most people use compression fittings, with two or three o-rings—two inside the push fitting, and one in the compression cap to reduce the chance of leakage.

For the rookie liquid-cooling enthusiast, it's advisable to start out on soft tubing first, being the easier of the two methods, then try your hand at hard tubing at a later date.

The Cost

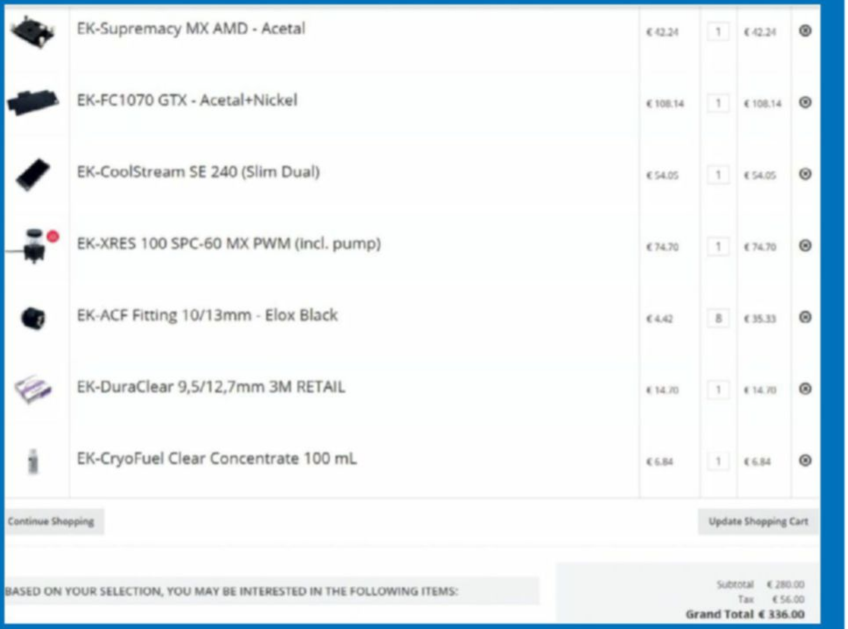
Two of the biggest complaints you'll hear when it comes to custom loop liquid cooling are about the cost and complexity involved. The tech press doesn't exactly help the matter either—ourselves included.

You often see monstrous Dream Machines and multi-GPU rigs, fitted out with the very best, complex liquid cooling setups, that come in at a price for which you could easily build an entire decent system.

The reality is that these liquid-cooled leviathans are fringe experiments. Anomalies. And apart from the tubing, you'll often find you can reuse almost all the components over and over again. Radiators can be flushed, CPU blocks (if it's not Threadripper) can be swapped over to new chips, fittings still operate fine (as long as you don't lose the o-rings), and reservoirs and pumps can function perfectly for years. For very little cost, just like an AIO, you can take a full liquid-cooled loop, and with a bit of tubing, migrate it to a new system, to a new CPU, or even expand it.

The most difficult cost to stomach, however, is probably that of the fittings. Although each block can come in at anywhere from $60 to $120, each standard fitting comes in at about $6, with special angled fittings and others costing $10 or more. When the average full loop can use close to 20 or 30 fittings, that soon starts to add up.

That said, it's likely the complexity that puts off the majority of first-time liquid-coolers. Let's say you want to create a simple loop for your CPU. You need a radiator, a pump, a reservoir (or res combi), a CPU block, some tubing and coolant, and a minimum of two fittings per component you use to cool the system. That's a lot to consider.



EK-Supremacy MX AMD - Acetal	€ 42.24	1	€ 42.24	⊗
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EK-CoolStream SE 240 (Slim Dual)	€ 54.05	1	€ 54.05	⊗
EK-XRES 100 SPC-60 MX PWM (incl. pump)	€ 74.70	1	€ 74.70	⊗
EK-ACF Fitting 10/13mm - Elox Black	€ 4.42	8	€ 35.33	⊗
EK-DuraClear 9,5/12,7mm 3M RETAIL	€ 14.70	1	€ 14.70	⊗
EK-CryoFuel Clear Concentrate 100 mL	€ 6.84	1	€ 6.84	⊗

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The price of your liquid cooling components can soon add up.

The Danger?

Let's not beat around the bush: As with anything PC-related, there's always going to be some risk involved, especially when working with liquid. Whether that's not installing a fitting correctly, not using the correct length of tube, or forgetting to plug a hole, the risk is there. You're always going to hear horror stories of liquid cooling going wrong, or loops suffering leaks after prolonged periods of use. The reality is, these events are quite rare. As long as you take your time, follow the instructions, and do things correctly, it's unlikely you'll ever encounter these issues, any more than you would encounter a dead AIO.

And, of course, there are precautions you can take to reduce the chance of a mishap. Things such as making sure your power supply fan is facing down, priming your loop with everything bar the pumps disconnected, making sure that each fitting is secure using the included Allen wrench, using the correct length of tubing, and not cutting corners are imperative. It's also advisable that after you've first built and primed your loop, you run the loop for a full day, with everything disconnected, to check if there are any leaks, using paper towels as indicators.

Even we've had our fair share of liquid cooling mishaps and leaks in the past, yet not one crucial piece of hardware has died because of it. Our ITX liquid-cooled build back in July 2016 suffered a failed o-ring on one of the angled fittings atop the Fury X GPU, leaking down off the block and on to the PSU (which, fortunately, had the fan facing down), likely due to too much pressure and not enough tube. And even in our latest build, we had to drain the loop and reseat the memory.

One of the biggest concerns we hear is the fear of mounting the blocks incorrectly. Ironically, this is the safest part of the whole job. The blocks themselves are completely sealed units—simply put, no coolant ever touches the component. Take a graphics card block, for instance. The block makes contact with the GPU, the memory, and the VRMs (usually with thermal paste for the GPU, and thermal pads for everything else). Coolant then flows around the block, drawing heat out from the nickel, copper, or, in this case, aluminum, through pre-milled channels, and out toward the radiators, where it's cooled.

The biggest risk comes from removing the stock cooler from the card; most liquid cooling manufacturers include instructions on how to remove the stock coolers. Take your time, use the correct tools, and you'll be fine.

The Worth

So, the big question: Is it worth it? The short answer is: It depends. Ultimately, all cooling operates via a form of convection. If you're using an air tower or stock cooler to chill your GPUs and CPUs, cool vapor becomes heated at the center of the GPU or CPU, rises through the heat pipes to the outer edges of the block, where it's cooled by a fan, and then sinks down once more to draw heat away from the processor again, in a continuous cycle.

Is it worth it? Hell, yes!

Liquid cooling operates in a very similar fashion, just on a far grander scale. The cooling fins or surface area are far greater, due to the use of thicker, larger radiators, and the vapor is replaced with coolant, capable of transferring a far greater amount of heat than its low-key counterpart.

The advantages of that, apart from the greater surface area available to a radiator, is that the heat is then dispersed away from the components involved, rather than right next to them, meaning temperatures drop much faster. Additionally, in contrast to an air tower or GPU stock cooler, you can run radiator fans at a fixed speed. As long as air is passing over the fins, due to the vast quantities of coolant, combined with that larger surface area we mentioned, the radiator does its job effectively and radiates heat away from your components. And because you don't need to run your fans on such an aggressive profile, it also means you reduce noise levels in the process as well.

In the end, what you're left with is your very own bespoke system, designed to your spec, with a color of coolant you want, that's far quieter and cooler than if you were to operate at stock.

Of course, it's still going to cost you, so whether liquid cooling is worth it to you depends on how much you value lower temperatures and less noise. We can drop analogies, metaphors, and similes all day about how much more enjoyable a liquid-cooled system is, but you have to experience it to understand the difference going from an AIO to a custom loop.

Measuring Performance

If you've decided to give liquid cooling a go, you're going to want to do some benchmarking, to see how much of an effect it has had on your build.

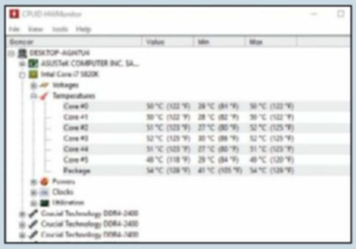
We recommend you download CPUID's HWMonitor. It's a neat piece of freeware that pumps out all sorts of system info, including temperatures of a whole variety of system components, including your CPU and GPU.

Next on our list is Prime95. Designed to search for Mersenne prime numbers, it's one of the most aggressive torture tests out there for stressing your processor. Finally, for your GPU, grab FurMark—or, if you fancy dropping the cash, 3DMark's Fire Strike.

First up, reboot your system, open up HWMonitor, and take note of the idle temperatures of your processor (you'll want the "package" temperature) and your GPU. Next, load up Prime95, check the box that says "Just Stress Testing," then select "Small FFTs" for your torture test. Run this for around 10 minutes, before hitting "Test" in the toolbar, then "Stop." Note down the max temperature in HWMonitor, then click "View" and "Clear Min/Max," to reset the figures for your GPU tests.

For your graphics card, keep HWMonitor open, start up FurMark, and run a single instance of your screen's resolution, with x4 AA (do the same with Fire Strike, depending on what resolution you game at). Leave this for 10 minutes (or the duration of the run), note down the max temperature in HWMonitor, and close the applications.

Once your liquid cooling is set up, repeat the process to see the improvement. If you're on air cooling prior to changing, run Prime95 until you hit your CPU's max temperature (without thermal throttling), stop Prime95, and time how long it takes the CPU to return to its idle temperature.



HWMonitor is your friend—unless using Ryzen, then HWInfo is.

The Plan

Although plans often have to be adapted to suit your case, the environment, and the parts you have, planning in advance is crucial to building an effective loop. And even with liquid cooling, you still need sufficient internal airflow, so removing all internal fans is a no-no.

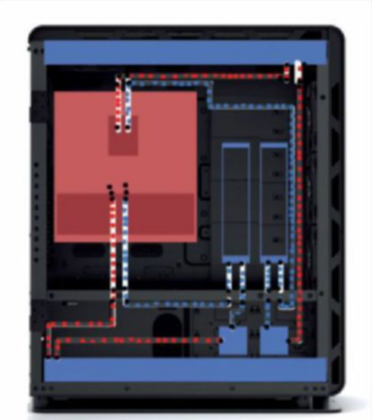
There are a few things to consider when building a liquid-cooled loop. First and foremost, your pump should always be gravity fed by a reservoir. Think of a pump as a fan—the bearing at its center needs to be well lubricated to function. In a liquid cooling scenario, the coolant acts as lubricant. If you don't have lubricant in the pump, you risk damaging the bearing and killing your pump.

You should also note which ports on your devices are inlets and outlets. Traditionally, on a pump, the outlet is the lowest port, and the inlet is anything above that—but check the manual. CPU blocks are usually labeled, and it often doesn't matter for radiators and graphics cards.

Then it's simply a case of creating a full loop. In a very simple instance, we'd run a length of tubing from the pump to the GPU, from the GPU to the CPU, the CPU to the radiator, and the radiator back down to the reservoir pump combo. If we were to add an additional radiator, we'd likely run the first radiator directly to that second rad, then back down into the reservoir again.

Radiator positioning in liquid cooling loops doesn't actually matter. Thanks to the laws of thermodynamics, in a pressurized system such as this, the temperature of the coolant is the same across all points within the loop. So, whether you place one radiator before or after a component, it makes very little difference to internal temperatures.

On top of all this, you still need to consider your fan setup. Make sure you have either a balanced or a slightly positive setup, drawing cool air into the chassis from the front, and exhausting out of the roof or the rear of the case.



Preliminary plans for DM 2017.

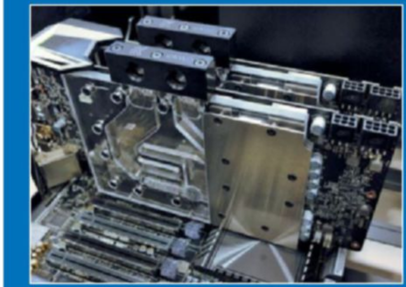
The Choice

If you're investing in one of EK's DIY kits, deciding what to cool is quite easy: Do you buy a CPU kit, or a CPU and GPU kit? If you're speccing up your own loop from scratch, however, the decision is more complex, but we reckon you may as well cool the GPU and CPU on your first pass.

You can cool memory as well, and the VRMs on motherboards, but at additional cost and risk—particularly for DDR4, as you have to remove the stock heatsinks to mount the liquid-cooled waterblocks. In most scenarios, liquid cooling memory is more for aesthetics than performance. VRMs, on the other hand, may provide significant benefits for overclocking. For that, you need to buy a motherboard with integrated liquid cooling support, or invest in a "monoblock," specifically designed for your motherboard, that simultaneously cools the CPU and its surrounding VRMs.

There's also the choice of how many loops. Splashing out on two custom loops is popular. In theory, running each set of components in isolation can reduce overall temperatures, by reducing the temperature of the coolant. For instance, if your GPUs aren't under load but your CPU is, the GPU idle temps are probably higher in a single loop, due to the increased temperature of the coolant within the pressurized loop. It also looks stellar.

Next, you need enough radiators. The rule of thumb is 120mm of radiator for every component you cool (excluding memory, VRMs, and such), and an extra 120mm if you intend to overclock.



GPU blocks? CPU blocks? Memory? What's best to cool?

The Expansion

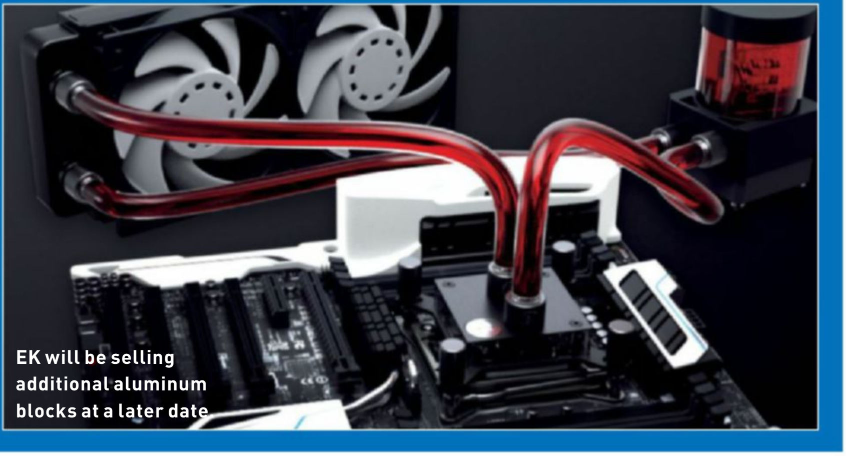
One of the most crucial things to be aware of when liquid cooling is that you should never mix metals within the loop. For instance, never mix copper with nickel, or even zinc-plated copper, as this can damage the components within the loop, and cause a build-up of matter in your system that can clog and eventually kill your loop entirely. EKWB's Fluid Gaming Kits are one of the first to be constructed from aluminum. Designed to save cost for the end user, these components must only be used with other aluminum products, though, and should not be mixed with either copper or nickel.

EKWB has said that it will eventually be selling the individual components separately. So, if you do want to add an additional graphics card or radiator to the mix, you will be able to do that at a later date. But, again, only aluminum parts—no others.

Outside of the world of all-in-one kits, how do you go about expanding your loop? Well, first we're going to need to cover a little bit about loop maintenance. By default, you're going to want to drain and refill your loop at least once a year, to reduce the risk of any build-up of matter in the coolant—preferably every six months. To do that, it's advisable to ensure you include a drain port at the planning stage.

Generally speaking, these are ball valves, or a standard block fitting with a cap, and should be located at the very lowest point in your loop—preferably below your radiators, too. To drain your loop, you're going to need to depressurize the system. With a length of tubing attached to your drain valve, then to a bucket, open the valve, then proceed to remove one other plug, ideally above your reservoir, to allow air to pass through the system, and the coolant to drain out. If your reservoir cap doesn't have any fittings, simply remove the top of the cap.

Then it's a case of slowly rotating the system, to get any remaining coolant trapped in blocks out of the loop, and you're OK to continue disassembly. At this point, you can add more radiators and other liquid cooling hardware to your loop. Simply prime the loop again with fresh coolant, and you're good to go.


EK will be selling additional aluminum blocks at a later date

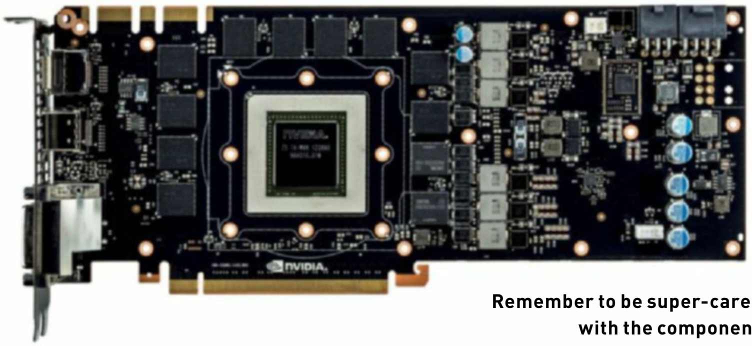
The Coolers

One of the most challenging tasks is learning how to remove stock coolers from graphics cards. And if you do remove your stock cooler, you're probably about to void the warranty on that GPU. It's a big undertaking, but as long as you use the correct tools, take your time, and follow the instructions provided with your waterblock, you shouldn't have any issues.

There's a few things to note at the outset. When you buy your waterblock, make sure you get one that's compatible with your card. Most manufacturers offer a variety of blocks, most commonly for reference cards first, then additional models for aftermarket cards with custom PCB and power-phase designs at a later date. For instance, if you've got an MSI GTX 1080 Gaming X, with a Twin Frozr VI cooler on it, make sure you buy the TF6 card, and so on.

Additionally, the stock heatsink removal process for graphics cards is different, depending on the manufacturer. For instance, a stock Nvidia cooler requires a 4mm hex socket screwdriver to remove the screws underneath the backplate, while the MSI card we mentioned earlier only requires a standard Phillips head screwdriver. It's worth taking a look at the instructions before you even invest in the card, just to make sure you've got the tools necessary to do the job.

That aside, the best advice we can give is to start by removing the screws on the backplate, then the rear I/O, before gently wiggling the cooler slightly to remove it from the card. Be very careful, and remember to unplug any fan connectors or LEDs before yanking it off. Once again, we can't stress enough just how important it is for you to stick to that instruction manual like glue, because you'll have a far easier time if you do. Additionally, after you've finished your deconstruction, keep all the original screws safe in a ziplock bag, in case you decide to remount the original cooler at a later date.


Remember to be super-careful with the components.

The Conclusion

The big question: How effective are EK's Fluid Gaming Kits? The honest answer: very. Being keen liquid-coolers, piecing this build together and then converting it to liquid cooling went a lot more smoothly than we thought it would.

We took a chassis that wasn't the most friendly to work in for liquid cooling, but still had a satisfyingly smooth run to the heady heights of liquid nirvana. The Crystal 570X is a nice glass chassis—if you can stand the smudges—but liquid cooling really isn't its forte. Sure, the radiator spacing is there, but there is little consideration for things such as pump or reservoir mounting. That said, there weren't any particular problems we had to work around with it. We took our trusty Dremel 3000 to the floor, unscrewed the case feet, drilled some small mounting points for the pump res combi, and the job was done. EK did also provide us with a radiator bracket to mount the combi to, in case we didn't have a Dremel to hand.

It was the cooling that really blew us away, though. Typically, we've almost always taken advantage of Intel's processors to liquid cool in the past—however, this time around, we decided to go with Ryzen for a change of pace, and to see what happened when we cooled the mighty eight-core with something a little more substantial. We were particularly dubious when it came to adding a GPU to that loop, though, especially with just a slim 240mm radiator.

The result? Well, we were pleasantly surprised. The drop in temperature we witnessed when we transferred over to liquid cooling on the graphics card, even with the CPU in the loop, and running more processor-intensive DX12 benchmarks, such as 3DMark's Time Spy, was incredible.

As far as CPU temperature went, there wasn't a huge disparity between that and the stock RGB cooler that AMD provided, with an 11 percent difference at most. It still made it a worthwhile jump, but nothing as crazily impressive as the drop we saw with the graphics card.

Power draw was one of the more intriguing tests we ran. Even though we only added one pump and two extra fans to the mix, the idle power draw went up by 31W, and the load draw jumped by 16W. Interestingly, EK's small form factor pump operates from a single PWM header, as opposed to a header and SATA power, like EK's beefier pump solutions. Although this does reduce power draw, it also reduces flow rate, which may be something to bear in mind for heftier systems if you decide to expand beyond the base kit.

As for that power draw variance at both idle and load (31W difference at idle, and 16W at load), we can only assume this is due to the cooling solution not being ramped up. Unlike the stock air coolers used on both the GPU and the CPU, our liquid-cooled loop's three components ran on a fixed voltage, meaning they had no need to spin up when the temperature increased across the two parts.

Ultimately, EK's Fluid Gaming Kit is an easy way to have a quick venture into DIY liquid cooling. If you're new to the concept, or just fancy a quick and easy build, it's well worth a look. Invest in some colored dyes, and you can have a purple loop like ours in no time.

MAKE YOUR BUILD
LEGENDARY
EK FLUID GAMING

EKWB's Fluid Gaming Kit laid bare.

The Overclocking?

So, how is the overclocking on a system like this? Well, by default, Ryzen's pretty silicon is locked when it comes to overclocking. With all the will and cooling in the world, you'll struggle to get past 4.0GHz, unless you're exceptionally lucky with the silicon lottery, or you have some liquid nitrogen handy. Stability will have you beat long before thermals do.

That said, there are two advantages to this loop when overclocking the GTX 1070. By default, GPU Boost 3.0 automatically raises the clock speed of the GPU depending on temperature. The lower the temperature, the higher the clock speed. Raise the power target to 110 percent and temperature to 91 C, and it'll go higher still.

INGREDIENTS

PART		PRICE
CPU Block	EK-Supremacy MX AMD—Acetal	$50
GPU Block	EK-FC1070 GTX—Acetal+Nickel	$128
Radiator	EK-CoolStream SE 240 (Slim Dual)	$64
Pump/Res	EK-XRES 100 SPEC-60 MX PWM (including pump)	$88
Fittings	8x EK-ACF Fitting 10/13mm—Elox Black	$42
Tubing	EK-DuraClear 9,5/12,7mm 3M Retail	$17
Coolant	EK-CryoFuel Clear Concentrate 100ml	$8
	Total	$397

The cheapest standard loop equivalent versus EK's Fluid Gaming Kit A240G.

EK Fluid Gaming Kit A240G: $240

GPU TEMPERATURES

	ZERO-POINT	
Idle Temperature (C)	25	22 (12%)
3DMark: Time Spy (C)	71	41 (42%)
3DMark: Fire Strike Extreme (C)	62	38 (39%)
Rise of the Tomb Raider (C)	72	40 (44%)
Far Cry Primal (C)	63	43 (32%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our zero-point figures relate to the build before the liquid cooling features were added.

CPU TEMPERATURES

	ZERO-POINT	
Idle Temperature (C)	45	43 (4%)
Prime95 Burn Test—Small FFT (C)	82	73 (11%)
Cinebench R15—Multi (C)	78	73 (6%)
X265 Benchmark (C)	93	86 (8%)
PCMark 10 Home—Express (C)	74	70 (5%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our zero-point figures relate to the build before the liquid cooling features were added.

SYSTEM BENCHMARKS

	ZERO-POINT	
Power Draw Idle (W)	51	82 (-61%)
Power Draw Load (W)	141	157 (-11%)
Time to Remove Heat (s)	26	18 (31%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our zero-point figures relate to the build before the liquid cooling features were added.

How We Tested

We decided to stick with temperatures and system power draw for this feature. If you're looking for performance figures, head over to "Build It" on page 70 to get the lowdown. All temperatures are the highest recorded over the duration of the benchmark. Prime95 was run for five minutes, Cinebench R15 was run three consecutive times, with all other benchmarks running for a single instance. Each GPU test was a single instance, with both games being run at 1440p, on the highest graphical preset. "Power Draw Load" was one standard instance of Prime95's burn test, over five minutes.

For our final figure, we measured the temperature of our processor at idle, ran an instance of Prime95 with Small FFTs until the processor temperature wouldn't increase any more. Then we canceled the instance of Prime95, and timed how long it took for the processor to return to its idle temperature.

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ALL ABOUT USB

Over 10 billion sold, and counting—how USB changed everything. *By Chris Lloyd*

IT HAS BEEN CALCULATED that there are, on average, 13 Universal Serial Bus ports within 30 feet of you right now—amazing. USB first appeared on PCs around 1996, and has done very well ever since. By the new century, it was everywhere. USB ports are on cameras, cell phones, MP3 players, printers, and in your car. Everywhere. It has, indeed, almost become universal. Is there really an average of 13 ports around you? No idea—we made that up, but it sounded believable, didn't it?

Why has USB become so successful? The original technical specifications were reasonable for the period. Sockets and plugs are simple and therefore cheap. It includes power—enough to drive a small device or charge a larger one. You can plug things in and out at will, something we've got so used to now we that forget you used to have to reboot a lot to get things working. It has another vital ingredient of many successful standards: no royalty payments. If you want to use the official logos on your gear, you must get it past the compliance testing, and pay a small fee. That's it—you don't have to pay a kickback on every USB device you sell. And, lastly, there is the mess that it replaced.

In the early '90s, most peripherals had their own connection. Your keyboard had a chunky IBM AT five-pin plug, the mouse wanted a nine-pin serial port, the printer its own 25-pin parallel port. The newfangled modem required an RS-232 serial port. SCSI drives needed a SCSI port. IBM's PS/2 keyboard and mouse ports were neater, but were essentially just smaller versions of the existing ports. The proliferation of standards made coding difficult, and added lots of ungainly sockets to motherboards. If you developed a new peripheral, where would you plug it in? The world was rapidly digitizing, and the average computer had no suitable free ports to plug anything new into. Peripherals often resorted to shipping with their own expansion card to carry the port they needed.

USB WAS TO BE a single high-speed standard to connect all external devices. Work started in 1994, and seven big players got together to hammer out the details—Intel, IBM, DEC, Compaq, NEC, Nortel, and Microsoft, with Intel's star techie Ajay Bhatt playing a key role. The first silicon appeared in 1995. By the following January, standards were agreed, and it was rolled out on PCs. When support was added into Windows 95 OSR 2, it began to proliferate. By 1998, it was established enough for systems to start dropping the old ports altogether—Apple first, of course. By the time USB 2.0 came along in 2000, it was an unqualified success. That year also saw the first USB flash drive from IBM (or memory stick, or pen drive, or thumb drive, or a multitude of other names), all 8MB of it. Today, the USB standard is overseen by the USB Implementers Forum, a non-profit organization founded by many of the same people behind the original specifications.

USB consists of two parts: the physical standards for the plugs and wires, and the technical specifications for power and data transfer. Serial transfer was chosen over parallel because, while technically faster for the same clock speed, parallel data transfer is difficult to do over a long cable at speed. Problems with timing and interference are tough to crack. It also requires lots of data lines, which means big plugs and thick wires, which all add to the cost. From the start, USB was planned as being very cost-effective.

The original USB 1.0 of 1995 had a Low Speed mode, running at 1.5Mb/s, which equates to 187.5KB/s. USB 1.1 soon followed in 1998, and introduced a Full Speed mode of 12Mb/s, or 1.5MB/s. This was the first widely implemented version, good enough for simple peripherals. In 2000, USB 2.0 introduced a High Speed mode, with a data rate reaching a more useful 480Mb/s, or 60MB/s. It also introduced a battery charging mode. This starts to get more useful; file transfers and other more demanding tasks became viable.

2008's USB 3.0 (also now known as USB 3.1 Gen 1, essentially the same thing) added a SuperSpeed transfer mode of 4Gb/s. Actually, it's higher, at 5Gb/s, but the addition of 8b/10b encoding costs 20 percent of the bandwidth (8 bits of data recovered for every 10 bits sent). It's often quoted as capable of 60MB/s, but in action it starts to top out at around 3.2Gb/s, which is 400MB/s. Now USB is starting to become a viable means to shift large amounts of data, and connect external drives.

Picking Up Speed

2013 brought us USB 3.1 and SuperSpeed+ mode (they are going to run out of superlatives at this rate). This raises the bar to a theoretical 10Gb/s, and a practical one of 7.2Gb/s, which equates to 900MB/s. The encoding changed to 128b/132b, giving a negligible 3 percent overhead. These super modes required double the data lines—the cables have an extra two pairs of data wires. Here we are in the realms of mass storage devices, such as SATA 600.

One of the boons of USB is the backward compatibility; in theory, you can plug pretty much anything into anything, and it works, not unlike PCIe. Obviously, to get SuperSpeed+, you need both device and controller to be USB 3.1, but you can still plug into lessor iterations of controller, and it does the best it can.

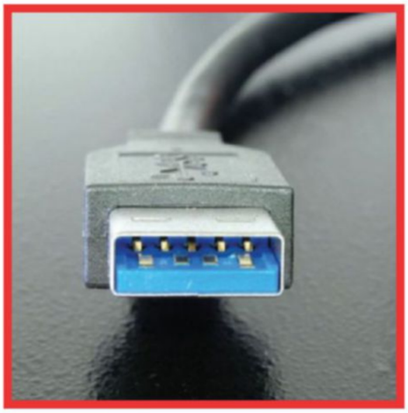
ANDREWA AT THE ENGLISH LANGUAGE WIKIPEDIA

Back in the dark pre-USB ages, every peripheral needed a different type of connector, such as this bulky five-pin plug for a keyboard.

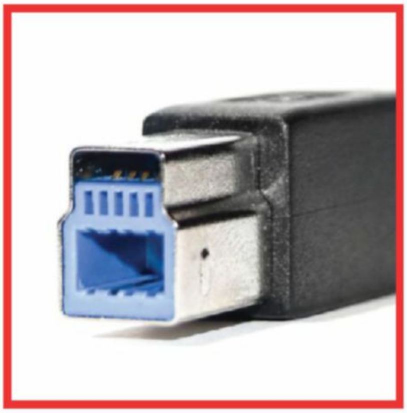
Adding power to USB was inspired. It cut out that ugly mass of transformers under your desk, and relieved the peripheral manufacturer of the cost of supplying one. The initial specification was for 500mA at 5V. USB 3.0 took this to 900mA for its increased data rates. And there's a charging mode, which can deliver 1,500mA. USB 3.1 has a Power Delivery mode that offers 5A at up to 20V, considerably expanding its potential as a charging format.

And now we come to a slightly annoying part. For such a universal standard, there's a fair number of different plugs and sockets. These fall into three groups: standard, mini, and micro. The standard type was designed for full-size desktops and peripherals. Type

USB has become the standard for attaching your keyboard and mouse, and for clever surround-sound headsets, too.

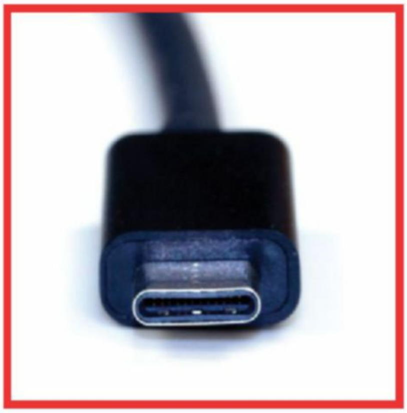


USB Type A: The blue tells us it's the SuperSpeed version. It's designed so that it can plug into a USB 1.1 or 2.0 socket, and speeds drop accordingly.



PICTURE BY ANIL ÖZTAS

USB Type B: Although less common than its counterparts, it supports everything from USB 1.0 to 3.0. It's often found in printers and more industrial peripherals.



USB-C, the best yet. It's small, doesn't mind which way you plug it in, and has enough data lines to cope with all current standards, even Thunderbolt 3 and over.

A is the familiar flat one used on memory sticks. Type B is square—for some reason, external drives and printers favor these. OK, it does stop you from plugging USB devices that must go into your PC into a peripheral that can't do anything with them, or getting too confused about what goes where. More practically, it means you need a different cable.

The mini-A and mini-B sizes are designed for mobile devices, although not used much these days. They have been "deprecated" to avoid a proliferation of standards. Micro-A and micro-B are intended for very thin gear, such as cell phones. As the plugs get smaller, they get more robust, as mobile devices are plugged in and out more often.

Then we have the SuperSpeed sockets and cables to accommodate the extra pins. There are SuperSpeed Type A, Type B, and micro-B. There is some useful backward compatibility here, too—you can plug an original into a SuperSpeed version. On most of these plugs and sockets, the chances appear to be more than 50-50 that you try to plug it in upside down.

On that note, we have USB-C, something of a departure. This can be used in both orientations, at last. It also allows power transfer in both directions. USB-C is favored by Apple, it's also appearing on increasing numbers of smartphones, and starting to appear on Windows laptops. It's not a USB standard as such, but a new expanded connector. It has a more substantial 24 pins—there is some redundancy here, depending on its use. The extra data lines add considerably to its potential longevity. It's small, neat, and a step up in design on previous versions.

"C" Change

Apple really went for it on its 2015 MacBook, which had just one USB-C port. This was not universally popular, as the first thing most users had to do was get an adapter so they could plug in a memory stick, or just about anything else, for that matter. Technically, USB-C, or Type-C (for some reason, C has a hyphen, but A and B don't), looks a good bet, although two years after its introduction, it's still the outsider. That will change, though.

USB-C is designed to replace all the current sockets, and alleviate the number of combinations that brings. The 10 standard socket types give us 21 possible cable combinations, not counting nonsensical

STRUCTURE, MODES, AND CABLES

USB is simple and flexible. It scales nicely, capable of running very basic devices, such as a keyboard, right up to demanding mass storage devices. It is all based around a single controller on the host machine. All communications are initiated by the host—devices cannot communicate directly with each other. Each device is assigned an address. The host controller sends packets of data, one bit at a time. Every connected device receives the data, but only the specified device responds, and only one device at a time can reply. Despite the huge number of devices you can connect at once, it essentially only talks to one at a time.

USB has four data transfer types, which help make it so flexible. Control transfer does the initial housekeeping and setup. Bulk transfer is for when it's vital you get every bit, such as file transfers—here, bandwidth and latency may suffer. Interrupt transfers are for peripherals that require a quick response, such as a mouse—latency is prioritized here. It involves regularly spaced transfers set by the device, the host collecting one packet at a time. Isochronous transfer prioritizes bandwidth, and there may be data loss. This is used for real-time video, such as webcams or audio, where keeping going is more important than the odd dropped bit. When you plug in a device, it passes a USB class code to the host controller, and picks the appropriate data transfer mode and type.

The original USB 1.1 standard allowed for a 3m (9 feet, 10 inches) cable. The limit was down to the time allowed for a device's response to a host request, as well as maintenance of signal integrity. USB 2.0 raised this to 5m (16 feet, 5 inches). SuperSpeed modes are more demanding. There is no specified maximum, but 3m is recommended. You can work around these limits by using powered hubs; each acts as a signal repeater, maintaining integrity and timing. As you can run five tiers from a host controller, you can reach 15m, if you really need it.

BIOS
BIOS
BIOS
SS
SS 10
TYPE C
WI-FI
SPDIF OUT
REAR
C/SUB
MIC IN
LINE OUT
LINE IN

Your motherboard defines how many USB ports you get to play with. More modern boards offer Type C connectors as well.

configurations, and a further 12 deprecated and non-standard ones. Realistically, you'll probably only need four or five USB cables to use nearly everything—even so, it's easy to get caught without the right combination at hand. Sockets and plugs are often color-coded. Standard ones are black; SuperSpeed are blue; yellow, orange, or red are for charging ports; and green ones are special Qualcomm Quick Charge ports.

The USB subsystem is built around a USB controller on a host machine, part of a motherboard's chipset these days. One USB controller can address a maximum of 127 devices—the controller itself counts as one device, so that takes us to the neat binary number of 128. Each USB device downstream is the end of the line, however; that's where the data lines end. Since there are no controllers in USB devices, no daisy-chains are possible. To attach more devices, you need a hub. This simply splits the wires out into more USB ports. If you connect devices that draw significant power, you need a powered hub, otherwise the 500mA gets shared out, too. USB supports up to five levels of branching. To the controller, your mass of devices appears as one long line with branches, each ending in a device.

USB is cheap to implement, especially in its simpler Low Speed mode. This, along with providing power, easy computer control, and its sheer proliferation, has made it an ideal platform for the strange world of the desktop toy, from kitsch novelty lights and fans through to the bizarre and frankly disturbing. Apart from the remote-control Nerf gun, of course, these are all great.

The number of USB ports you have on your rig is not necessarily the number of USB controllers you have. One controller can be wired to any number of ports through an internal hub. Intel's X99 chipset, for example, has up to 14 USB ports, according to the literature; up to six configured as USB 3.0, the rest as USB 2.0. However, it only actually has three USB controllers: one USB 3.0 and two USB 2.0. More recent chipsets are more lavishly equipped, using internal High Speed I/O lines. The Z170 has up to 10 HSIO lines available for USB 3.0. Remember that port, hub, and controller (or root hub) are three different things.

Thunderbolt from the Blue

If there is an industry standard, Apple will probably do something else. After the company's experiences with FireWire (see box below) it looked around for another high-speed interface to combine USB, PCIe, DisplayPort, and FireWire functions. It liked the look of Intel's Light Peak, originally designed for an optical connection. Under Apple, it emerged as Thunderbolt.

Version 1 and 2 used a Mini DisplayPort connector, while Thunderbolt 3 moved to USB-C. Despite its origins, it's all copper. The optical route was found to be an expensive one—and, anyway, it couldn't carry power, and the copper version proved faster than expected. Essentially, Thunderbolt is a combination of DisplayPort and four PCIe lanes mashed together (multiplexed) into two Thunderbolt lanes, and unscrambled at the other end. One port can support six devices, either through a

WHATEVER HAPPENED TO FIREWIRE?

USB's main rival in the early years was FireWire. In 1987, Apple, IBM, and others started working together on a new high-speed interface. By 1995, it was ready, and it was technically something of a triumph. FireWire—or IEEE 1394, as it is more properly known—could manage 400Mb/s in both directions simultaneously, supply up to 1.5A at 30V, and daisy-chain up to 63 hot-swappable devices. Apple added it to its Macs. Sony used it on its first generation of semi-professional digital video cameras. Microsoft and Intel took an interest. It looked as though it was going to be a thing.

On the cusp of success, the wheels started to fall off. The collaborative effort had also produced 261 patents across 10 companies. Apple decided it wanted $1 per port royalty payment. A fuss was made, and eventually the cost was dropped to 25 cents, which was to be distributed to all parties. The damage was done, though. Intel pulled out in a huff, and added USB support to its motherboard chipsets, rather than FireWire. USB had reached version 2.0 by this point, and the speed difference had eroded. Motherboard manufacturers could add USB at very little cost, while supporting FireWire meant adding an extra controller chip and paying royalties. Most didn't bother. Peripherals went with USB, and that was that.

Faster versions—FireWire 400 and 800—couldn't save it. In 2008, Apple started dropping it from new Macs; 2012 saw the last FireWire Apple product. There were other issues that didn't help: different non-compatible cables for each iteration, and confusing names (Sony called it iLink). It survives here and there, mostly in DV, but as a mainstream PC technology, it is dead. Royalty payments can make you a fortune—just ask IBM. However, they are always resented. If the success of a product is in the hands of others, then asking for substantial royalty payments is also asking for trouble.

The first flash drives managed 8MB. This is currently the world's largest, weighing in at 2TB, and $1,650 full price.

As USB-C and Thunderbolt take off, we'll see more of these; Apple does have a habit of removing ports before people are ready.

Wireless USB: It worked, now think of something to do with it that Wi-Fi can't do much faster and cheaper.

hub or daisy-chain, with the monitor at the end of the chain.

Thunderbolt 1.0 ran DisplayPort 1.1a and x4 PCIe 2.0 lanes, version 2 moved to DisplayPort 1.2. The big jump was Thunderbolt 3, which moved to PCIe 3.0, and threw in USB 3.1 and HDMI 2.0 support. Theoretical data rates doubled each time, from 10Gb/s to 20Gb/s, and with version 3, a not inconsiderable 40Gb/s. Real-world speeds are down ,of course; it has 128b/132b encoding, and various other overheads, but tests have version 3 in the range of 25Gb/s. So it's quick, which it needs to be if you're going to run a 4K screen and more.

Thunderbolt is not just for Macs; the full rights are back with Intel, and it has done the lion's share of the development, so anybody could, and will, use it. Windows laptops run it, and Intel recently announced that at some point next year, Thunderbolt will become royalty-free. Given that the specification includes USB 3.1, is it a rival? Yes and no. For the high end, it looks promising. For the mass market, it's far too expensive. A Thunderbolt hub capable of building your daisy-chain is the best part of $200; a USB one is barely $20. The on-board controllers are always going to be expensive.

While USB 3.1's SuperSpeed+ is fairly nippy, it doesn't quite match a single PCIe 3.0 lane. The next iteration is USB 3.2, tentatively due for release this fall. Data transfer rates are set to double to a theoretical 20Gb/s, which translates into a practical maximum of 1,800MB/s. It's to be called SuperSpeed++ (they did run out of superlatives after all). It's been designed around the USB-C connector, and existing cables are said to be compatible. Looks as if it'll use double the data wires. Don't get too excited yet, though—certification and validation are expected to take us into 2019 before we can take the hardware home. There's to be a series of USB Developer Days in September when we'll learn more.

It looks like USB-C is being groomed to be the main peripheral connection format, with both Thunderbolt 3 and USB 3.2 using it. One cable, one socket for everything from your monitor down to the most pointless USB desktop toy. Given the number of Type A devices knocking about, it'll be some time until we see the back of the familiar rectangular USB port, though you might have to buy an adapter or two at some point—but Mac people are used to that.

USB has brought a level of seamless connectivity that we now see as the norm. You just plug a device in, and off it goes. It has been hugely successful. It's killed off numerous rivals, from the chunky old parallel port to more capable ones, such as FireWire. The sheer number of USB devices in the world ensure it'll be around for a long while, and any replacement will have to offer compatibility. Its future lies with USB-C, and as a subset of Thunderbolt. USB's proliferation of cables and sockets will slowly resolve down to just one socket that'll be capable of nearly everything required for peripherals; truly universal.

WIRELESS USB: THE QUESTION NOBODY ASKED

In 2005, we were promised wireless USB. The idea seemed sound enough at the time. The USB Implementers Forum still has a page trumpeting the project. It points out that there are (or rather were—it is an old page) two billion wired USB devices. Wireless USB would bring the speed and security of a wired connection together with the ease of use of wireless. It would use Ultra Wide Band radio to establish a short range connection between host and device. At around 10 feet, it would offer USB 2.0 speeds. Performance dropped off with distance, down to a quarter of that at 30 feet or more.

Unfortunately, this proved a troublesome project. The regulations surrounding UWB are different all around the world, and there was considerable paperwork and negotiation to be done. It took until 2007 before anything was ready to launch; Belkin got as far as selling the gear. It proved unimpressive, data rates weren't as good as expected, and the range was severely limited, down to six feet for decent transfer rates. It was, at least, easy to use. Sales did nothing, and it died.

There was a rather obvious problem with the concept: Wi-Fi. All the major peripherals had already gone wireless: cheaply, with a decent range, and much faster. Ironically, USB proved the ideal port for the $20 Wi-Fi adapters it used. There's another fly in the ointment: no power. Cut off from the cable, your wireless USB hub needs a power source, so you need yet another transformer plugged in at the wall. Actually, if it's not too far away from your system, the best bet would be a USB cable. Oh, no—hang on. Quite.

There was actually a second stab at getting it going, around 2013. It was radically altered and called Media Agnostic USB this time. The concept used a range of Wi-Fi frequencies and standards. Unfortunately, the horse turned out to be dead after all.

TECH PORN

Sennheiser HD 650

ALONG WITH LAUGHTER, music is one of the few universal languages we humans have. Entirely subjective, based on personal experience and taste, enjoying those whimsical vibrations as they scatter through the air has captivated the minds of humanity for thousands of years. Whatever your musical poison, you can guarantee there's something out there for everyone. And once you've nailed down what you like listening to, the next step is deciding how you listen to it.

Whether your penchant is vinyl, high-resolution FLAC, or the likes of AAC, finding the perfect audio solution is key to enjoying this age-old medium. There's nothing quite like ramping up the volume on your favorite tracks, sitting back and really listening to every nuance carefully crafted by the artist. Sennheiser is one of the world's leading audio brands, and one of the few we immediately lean toward as soon as the temptation of fine-quality audio is on the horizon. When the HD 650s came our way, working alongside the Apogee USB DAC, we were truly blown away by the quality of these impressive cans. –**ZAK STOREY**

1 HEADBAND

This adjustable headband is one of the more comfortable ones we've experienced; the soft memory foam caresses the skull, and hides the aluminum band. There's angle adjustment on the cups, and full extension to allow even the largest of brains to rest easy.

Groove
APOGEE

2 APOGEE BUNDLE

You can buy this portable DAC headphone combo for $700 from Sennheiser, or $800 separately online. The Groove DAC is compact, easy to install, and provides crisp, reference-sounding audio, regardless of what you plug it into.

3 OPEN DRIVERS

An open-back design allows the maximum amount of air to surround the driver, providing a rich sound. Couple that with a nominal impedance of 300 ohms, and a frequency range of 10–41,000Hz, and it's a winner.

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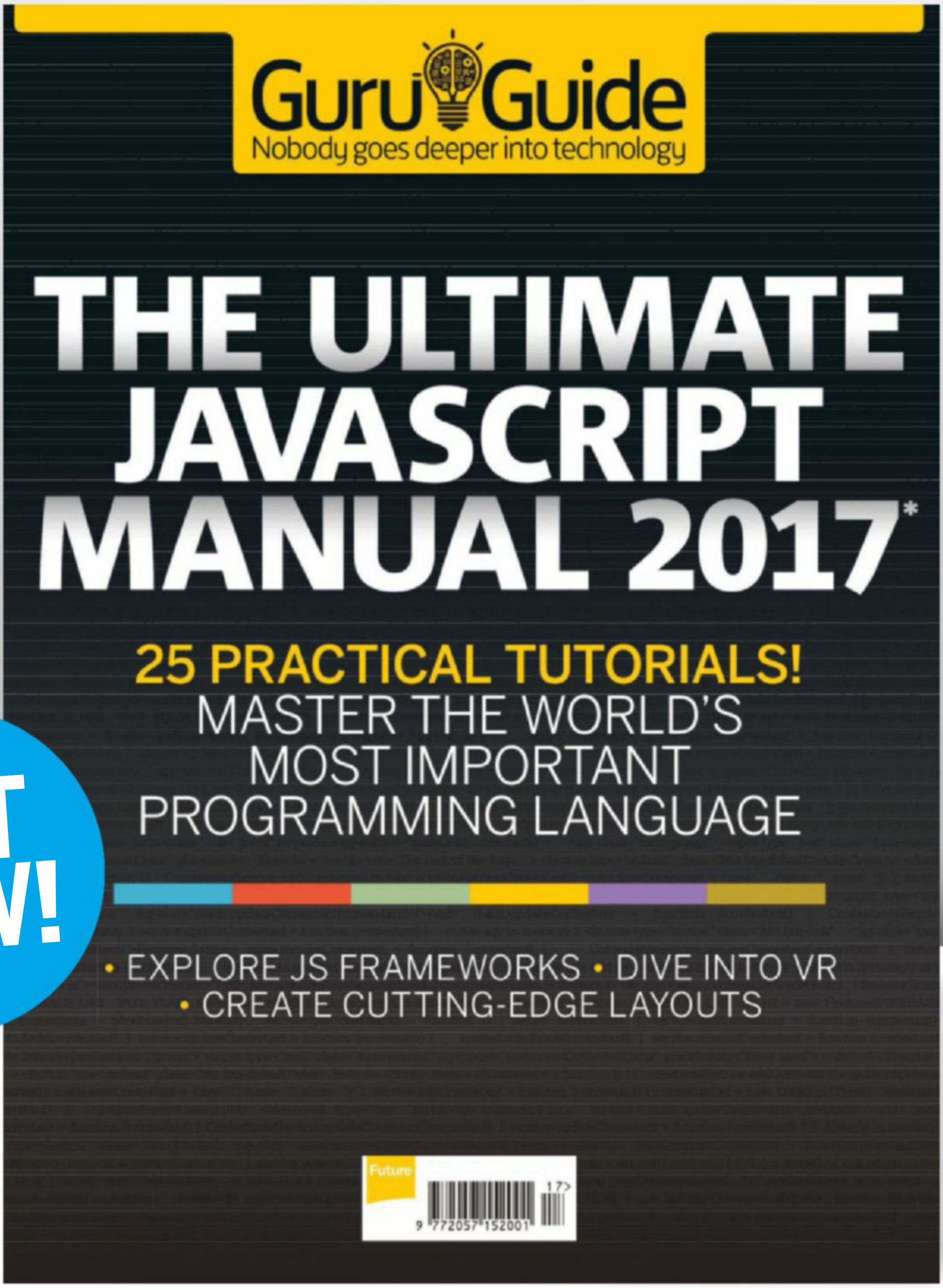

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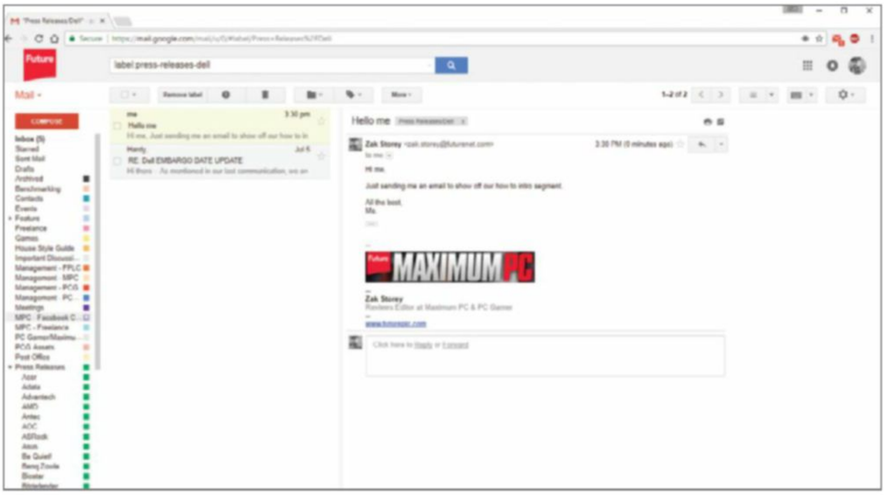


Hello me

Zak Storey

Hi me,

Just sending me an email to show off our how to intro segment.

All the best,
Me.

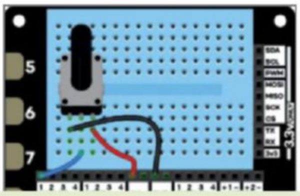
Zak Storey
Reviews Editor at Maximum PC & PC Gamer

PREVIEW IN GMAIL

Want to make Gmail function more like Outlook? Miss your email preview window? Don't worry, it's not gone. Simply click the settings cog wheel in the top-right, click the "Labs" tab, scroll down to "Preview Pane," set it to enable, and click "Save Changes" at the bottom. Then head back to your inbox, and just left of the settings cog wheel (past the keyboard input) is a button that says "Toggle split pane mode"—click that, and you're good to go. $Free www.gmail.com

MAKE – USE – CREATE

58
Control your home network with pfSense



62
Operate LEDs and motors with your Raspberry Pi

70
Build a kick-ass liquid-cooled Ryzen gaming rig

ZAK STOREY
REVIEWS EDITOR

STUCK WITH INTEL

It feels weird typing that headline. Yep, I'm stuck with Intel. And I don't want to be. I've had a taste of Ryzen and its crazy octo-core performance, and I'm entirely sold on the whole shebang. As I've mentioned before, the problem comes down to motherboards. I'm a small form factor fanatic, and there aren't any premium microATX Ryzen boards out there. For mATX, they all fall under the B350 chipset, which lacks I/O compared to its X370 superior; the only X370 ITX mobos around suffer from throttling when overclocking, due to a lack of substantial VRMs. And with Intel's latest X299 chipset being the monster socketed, power guzzler it is, we'll probably see a similar situation there.

That leaves me in an awkward position. I'm itching to move back to liquid cooling, particularly inside one of Phanteks' microATX Evolv TG cases, so I have two options: forsake my SFF fetish, and go full ATX in the standard Evolv, or stick with Intel, and grab an Asus ROG Strix Z270G.

The latter would satisfy my small form factor fancy, but it fails to address that rampant desire for more cores, and I'd need to 3D print out a rear I/O cover, too. Ultimately, this means—for the time being at least, until ITX is released from its seemingly damned destination—if I want to go with Ryzen, my only choice would be to take the ATX option.

↘ submit your How To project idea to: comments@maximumpc.com

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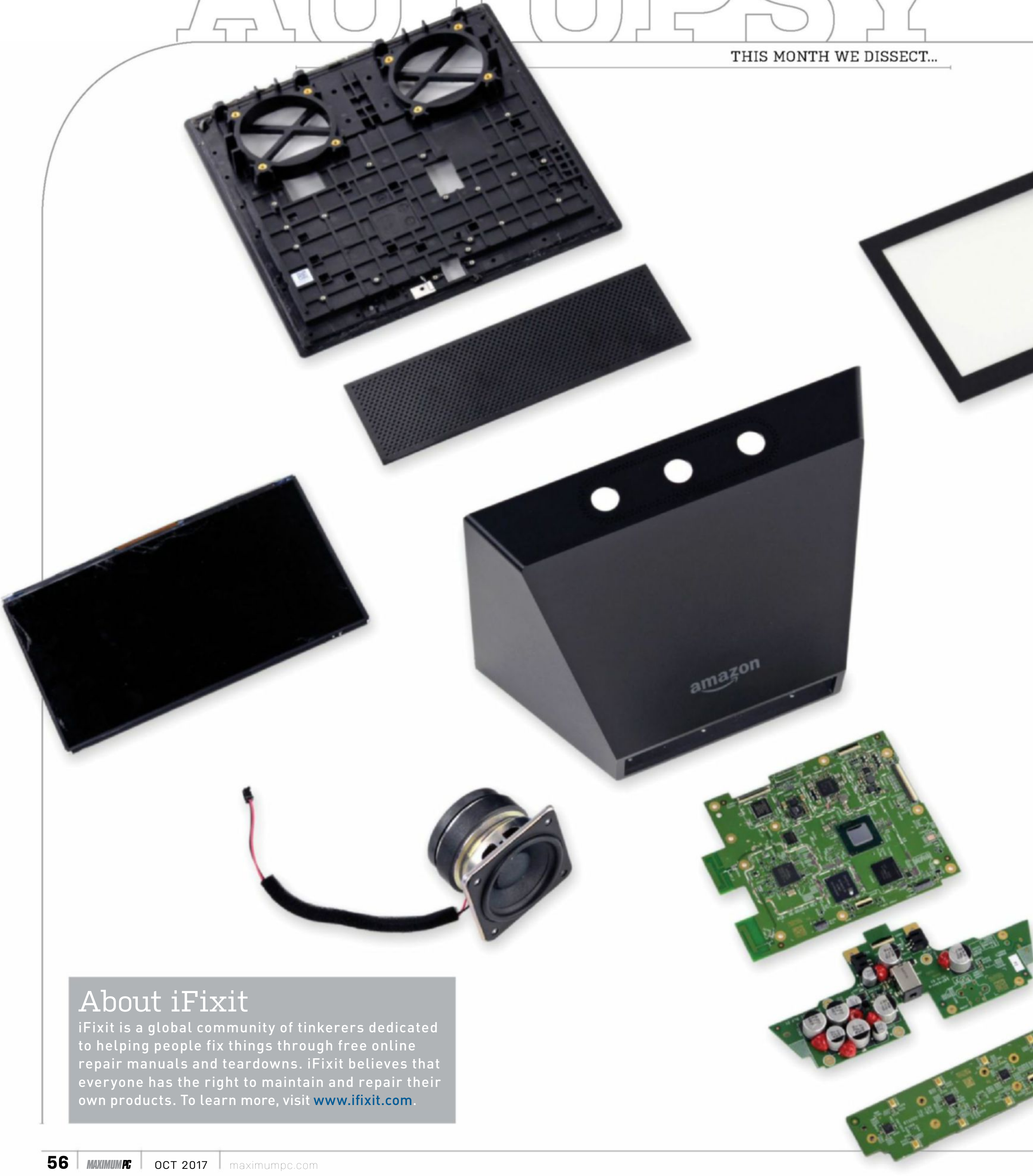

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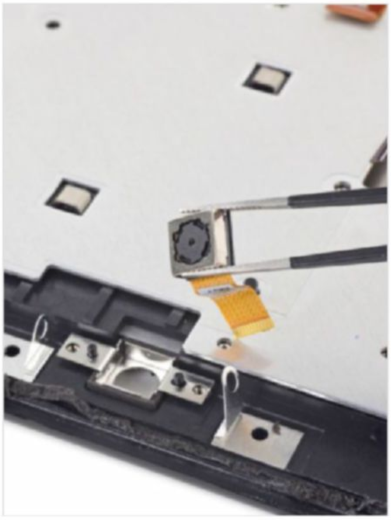
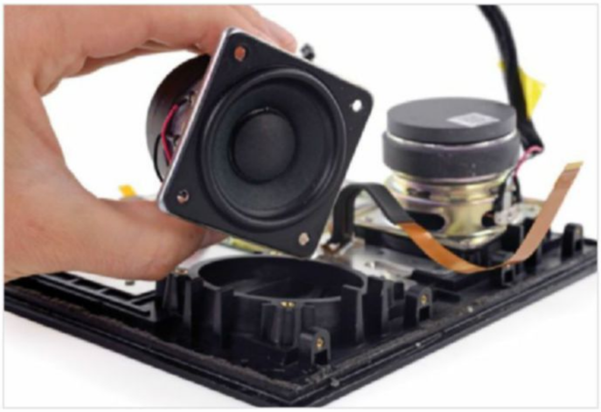
Amazon Echo Show

The "Show" part of Amazon's new Echo, a nifty 5MP camera.



Check out that humongous earthing cable.



BACKGROUND

Is there an echo in here? Seems like Alexa's talking to us from a lot of devices now. The new Echo Show adds a screen to bring even more Alexa, so she can watch you while she listens. Creepy? Maybe. Endearing? OK, yeah, a little. Hey, Alexa, let's "Drop In" on another teardown!

MAJOR TECH SPECS

- 7-inch touchscreen display with 1024x600 resolution
- Dual 2-inch stereo speakers
- Intel Atom x5-Z8350 (2M cache, up to 1.92GHz) processor
- 5MP front-facing camera
- Eight-microphone array

KEY FINDINGS

- Like most Echo devices, we start from the bottom. After peeling up the taped-in rubber foot, we spy a handful of T5 Torx screws. But with all screws dispatched, there are no seams—we seem to be screwed, for now. We hunt for new ingress points; it turns out the screws at the bottom were a red herring—the speaker grille is the real ingress point. Under the grille, we find some sound-dampening fabric (like the stuff rolled around the original Echo) and more screws.
- But still no dice removing that front panel—time to get to work on what looks like the digitizer. iOpener, engage! We lift the digitizer to reveal... more screws under the bezel! Unsurprisingly, the digitizer cable disappears into the frame, holding the digitizer captive for now. Fortunately, we can free the front frame, under which Amazon hid some hefty speakers. Our hard work and early screw removal pay off! Finally, we get to see what this Echo has to "Show" for itself.
- Alexa's new form is powerful. How powerful? Well, the wall adapter outputs 15V DC at 1.4A, meaning there's 21W driving Alexa. Someone needs to pull Alexa back down to earth, and luckily we spot a burly braided cable grounding the Show. That juice is going somewhere, and it looks like those speakers are thirsty. Out comes the main board, hiding its chips under an inscrutable jigsaw puzzle of EMI shields.
- The display itself is another matter. It's guarded by some impossibly tough foam tape that requires you to break the display rather than lift it out. So first we did the former, then the latter. The panel is a model TV070WSM-NMO, made by BOE. We half expected it to be borrowed from the similarly-specced Kindle Fire, but it's not one we've seen before.
- Repairability Score: 4 out of 10 (10 is easiest to repair). The Echo Show uses standard T5 and T6 Torx screws. While they may not get much wear, the most wear-prone components (buttons and power jack) are soldered to boards, which complicates replacement. The digitizer is not fused to the display, but must be pried up from tough adhesive to do any repair. The display is adhered tightly in the mid-frame, and is difficult to remove without damage. Any repair requires cutting through and replacing lots of tough adhesive. ⏻

Control Your Network With pfSense

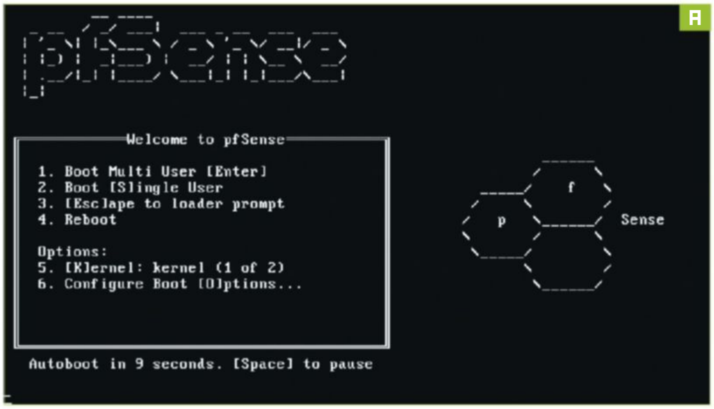
YOU'LL NEED THIS

PFSENSE
Download it from www.pfsense.org.

SERVER HARDWARE
Any 64-bit machine will do.

MANY OF US TRUST OUR HOME NETWORKS to sub-standard hardware we rent from our ISPs. We're not about to shoo that modem out of your front door—you'll still, most likely, need the right digitally signed hardware to get that broadband bitstream flowing—but the management portion is probably much better served by something that really knows what it's doing. What better than pfSense? It's primarily a firewall, but capable of much more, from routing to traffic management; run your Internet connection through it, and it takes care of everything. Many businesses rely on pfSense for their security but, if you're willing to roll up your sleeves, you can download and run it for free.

Intimidatingly, pfSense is actually a FreeBSD distro—a Unix-like architecture similar to and, in many ways, compatible with Linux. But don't let that worry you. Once pfSense is installed, you can configure and monitor everything through a simple web-based interface. All you need is some server hardware running a 64-bit processor (or an older version of pfSense that supports 32-bit hardware), the software itself, and some way of routing Ethernet traffic through that machine. A USB 3.0 Ethernet dongle should set you back no more than around $20.–**ALEX COX**



```
Welcome to pfSense
 1. Boot Multi User [Enter]
 2. Boot [S]ingle User
 3. [Esc]ape to loader prompt
 4. Reboot

 Options:
 5. [K]ernel: kernel (1 of 2)
 6. Configure Boot [O]ptions...

Autoboot in 9 seconds. [Space] to pause
```

1 THE RIGHT MEDIUM

First of all, head over to www.pfsense.org. Wade through the corporate stuff—as so many of these things are, pfSense is propped up by business implementation and support sales, but it's still free software—and head to the "Download" link, top-right. You're given a number of choices, which cover the architecture of the machine you'll be installing to, which in our case is AMD64, and the format, or platform, you would like to use. Whether you choose the CD or USB installation media is up to you, but it's worth bearing in mind that whichever one you use, pfSense installs itself to your hard drive, and you lose anything that's there already.

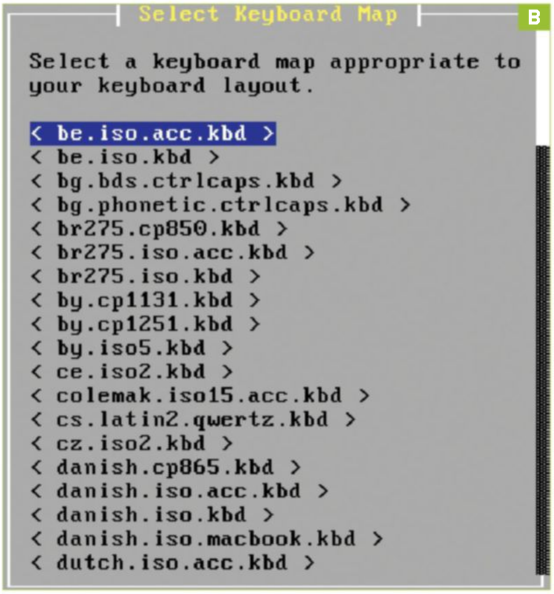
2 WRITE IT

If you select the USB installer, you can use Rufus (https://rufus.akeo.ie) to write it to a stick; for the disc ISO, use ImgBurn or the tool of your choice. Because the downloads come in gzip format, you do need to extract them using a tool such as 7-Zip (www.7-zip.org) before you can fill up your media. The machine you install it on obviously has to be able to boot from whatever media you choose, but other than that, there's not an awful lot that you need to consider. Around 1GB of RAM and a 1GHz processor is recommended, so your only real concern is putting decent Ethernet interfaces on the input and output. Don't cheap out on them, though, because a poor interface could hit your overall network throughput hard.

3 INITIAL INSTALLATION

Boot your hardware from your pfSense disc or USB stick. On the initial menu [**Image A**], select "Multi User" mode, then hit I to begin installation when prompted. You can safely ignore the console configuration screen, unless you're using an odd keyboard; if so, use the arrow keys to select it via the third option down [**Image B**], then choose "Accept These Settings" to move on.

» While there's an option to perform a quick install, the more granular action of a custom install is what we're after, so select that. Pick your target hard drive, formatting it when prompted, and sticking to the default geometry. You'll see an option to partition your drive, which would be handy if you were planning to put other operating systems on there—but you're absolutely not, since your pfSense server will be running 24/7/365, so don't bother with this. Install the bootblock on your primary drive (and your secondary disk, if that's where you've chosen to install



```
Select Keyboard Map

Select a keyboard map appropriate to
your keyboard layout.

< be.iso.acc.kbd >
< be.iso.kbd >
< bg.bds.ctrlcaps.kbd >
< bg.phonetic.ctrlcaps.kbd >
< br275.cp850.kbd >
< br275.iso.acc.kbd >
< br275.iso.kbd >
< by.cp1131.kbd >
< by.cp1251.kbd >
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< danish.iso.macbook.kbd >
< dutch.iso.acc.kbd >
```
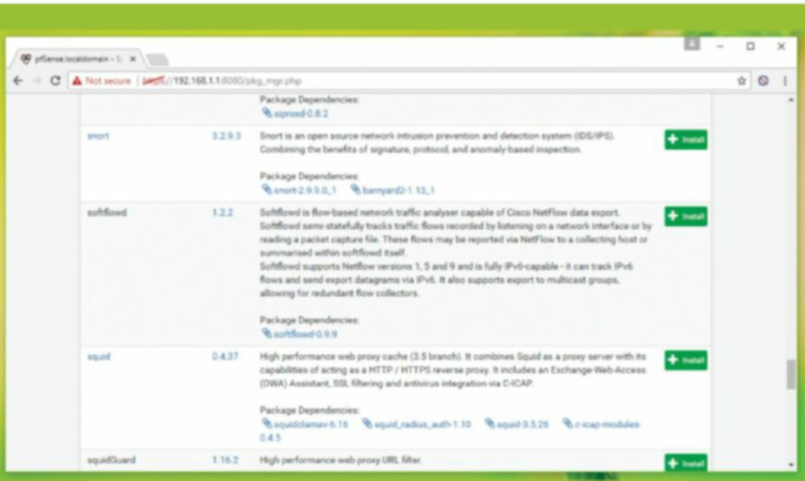

ADDING SKILLS

The core functionality of pfSense will be enough for some. It competently replaces all of the main functions of a router, and offers extra network protection. But there's more on offer, if you want it. Head to "System / Package Manager / Available Packages" to see all the add-ons in its holster—there's everything from community-driven intrusion detection system Snort to network discovery favorite NMap, each of which can be added with just a couple of clicks.

If you have a delicate family to protect from the horrors of the Internet, you might want to look at squidGuard, which adds a fully configurable URL filter to HTTP and HTTPS traffic, either whitelisting your chosen sites or blacklisting a list of known deviant locales. You can set it to act only on chosen local IP addresses—configure your kids' laptops with a static IP, and you can force them into a walled garden Internet without affecting your own ability to browse. Note that squidGuard and other URL filters can slow down browsing, and put a heavy load on your pfSense box, particularly if you use an extensive blacklist, so use sparingly.



		Package Dependencies: siproxd-0.8.2
snort	3.2.9.3	Snort is an open source network intrusion prevention and detection system (IDS/IPS). Combining the benefits of signature, protocol, and anomaly-based inspection. Package Dependencies: snort-2.9.9.0_1 barnyard2-1.13_1
softflowd	1.2.2	Softflowd is flow-based network traffic analyser capable of Cisco NetFlow data export. Softflowd semi-statefully tracks traffic flows recorded by listening on a network interface or by reading a packet capture file. These flows may be reported via NetFlow to a collecting host or summarised within softflowd itself. Softflowd supports Netflow versions 1, 5 and 9 and is fully IPv6-capable - it can track IPv6 flows and send export datagrams via IPv6. It also supports export to multicast groups, allowing for redundant flow collectors. Package Dependencies: softflowd-0.9.9
squid	0.4.37	High performance web proxy cache (3.5 branch). It combines Squid as a proxy server with its capabilities of acting as a HTTP / HTTPS reverse proxy. It includes an Exchange-Web-Access (OWA) Assistant, SSL filtering and antivirus integration via C-ICAP. Package Dependencies: squidclamav-6.16 squid_radius_auth-1.10 squid-3.5.26 c-icap-modules-0.4.5
squidGuard	1.16.2	High performance web proxy URL filter.

pfSense), then stick with the default subpartition configuration [**Image C**], which reserves a slice of drive space for swap (handy on low-RAM devices), and gives the rest up to the OS.

4 KERNEL PANIC

You can now select one of two kernel options, the kernel being the main controlling layer of the operating system. One gives you access to pfSense locally through a keyboard and VGA monitor, as well as through its web browser interface. The other, the embedded kernel, does away with these niceties in favor of slightly more efficiency. The only way you'll be able to control an embedded pfSense box is via its web interface and, if you want access to its BSD shell, by using an SSH client such as Putty (www.putty.org) on your desktop machine. If you're unsure of which you'll use, select the former.

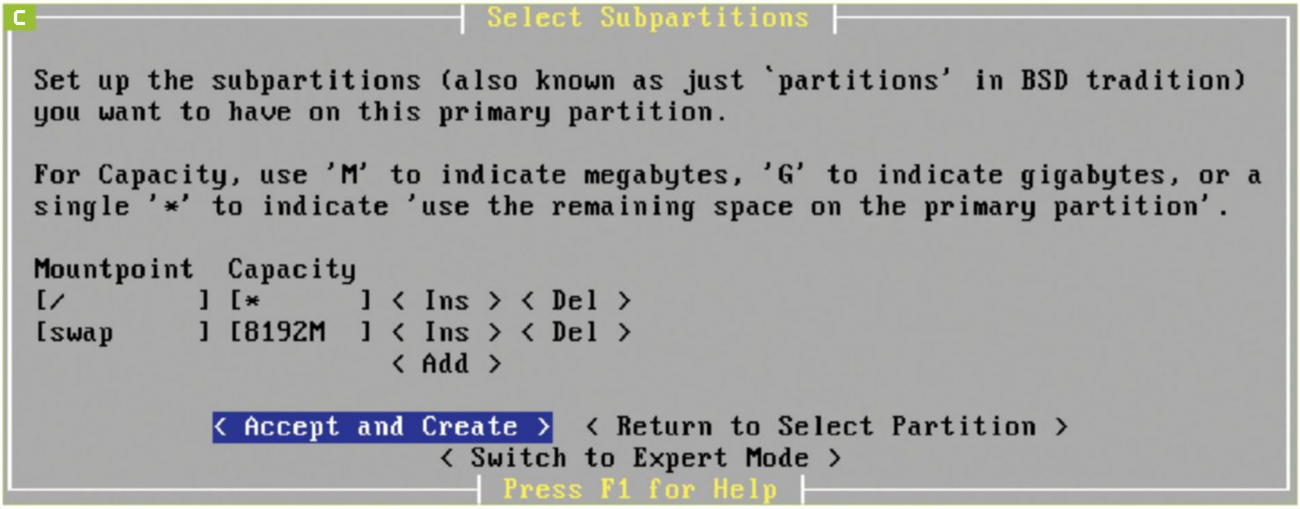
5 CONNECTING

Remove your installation media when prompted, and reboot your pfSense box. If you've elected for the full kernel, you'll now see a list of options [**Image D**], which includes, just above, information on your IP addresses—one for the WAN, or your Internet connection, and one, which you should note down, for your LAN. pfSense should sort these automatically, but you may need to assign them manually before you go any further; if you fumble on this step and select the wrong card for the wrong job, just switch your Ethernet cables. We won't tell anyone. Initial setup is done through pfSense's web interface so, for now, simply plug a machine directly into its LAN port. Fire up a web browser, and head to the address you noted earlier—probably 192.168.1.1—to begin configuration. If you get an alert about an invalid certificate, you need to bypass it for now.

6 CONFIGURING

Log in with the default username "admin" and password "pfsense," and the setup wizard begins. Sidestep the pleas to sign up for a gold subscription (you can do this later if you find you really love pfSense), and head to a bit of general configuration. Your hostname can be whatever you like, and set the domain, if you're already

C

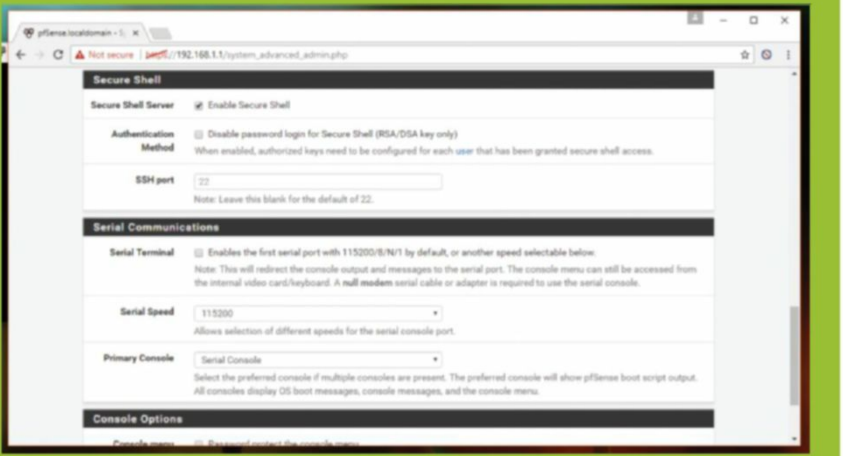


```
                         Select Subpartitions

 Set up the subpartitions (also known as just `partitions' in BSD tradition)
 you want to have on this primary partition.

 For Capacity, use 'M' to indicate megabytes, 'G' to indicate gigabytes, or a
 single '*' to indicate 'use the remaining space on the primary partition'.

 Mountpoint  Capacity
 [/        ] [*       ] < Ins > < Del >
 [swap     ] [8192M   ] < Ins > < Del >
                        < Add >

           < Accept and Create >  < Return to Select Partition >
                          < Switch to Expert Mode >
                             Press F1 for Help
```

COMMAND-LINE CONNECTION

Getting to pfSense's command-line shell can be incredibly useful, particularly if you know what you're doing with BSD. You can actually connect to it directly (though somewhat awkwardly) via the web interface—head to "Diagnostics / Command Prompt," and enter your shell commands in the top box before clicking "Execute." Experienced users will want to use the real thing, though, so click "System / Advanced," and check the relevant box to enable the "Secure Shell Server." We recommend changing the port from 22, too, because that's a commonly scanned location—giving a hacker access to your shell is just about the last thing you want to do.

With SSH activated, you can now use an app such as PuTTY (www.putty.org) to connect to pfSense's shell. Just point it toward the address of your pfSense server, and use the port you defined. Once you're in, you'll see a simplified menu—handy if you want to restart pfSense or perform other tasks without fiddling with the web interface—and an option to access the shell proper.



Secure Shell

Secure Shell Server ☑ Enable Secure Shell

Authentication Method ☐ Disable password login for Secure Shell (RSA/DSA key only)
When enabled, authorized keys need to be configured for each user that has been granted secure shell access.

SSH port 22
Note: Leave this blank for the default of 22.

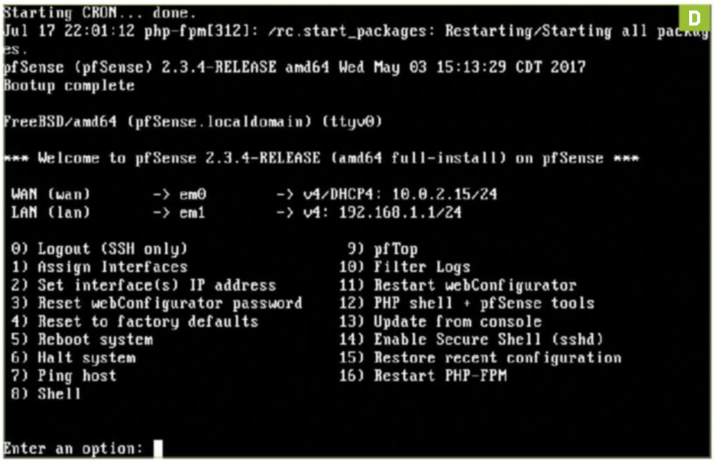
Serial Communications

Serial Terminal ☐ Enables the first serial port with 115200/8/N/1 by default, or another speed selectable below.
Note: This will redirect the console output and messages to the serial port. The console menu can still be accessed from the internal video card/keyboard. A **null modem** serial cable or adapter is required to use the serial console.

Serial Speed 115200
Allows selection of different speeds for the serial console port.

Primary Console Serial Console
Select the preferred console if multiple consoles are present. The preferred console will show pfSense boot script output. All consoles display OS boot messages, console messages, and the console menu.

Console Options



```
Starting CRON... done.
Jul 17 22:01:12 php-fpm[312]: /rc.start_packages: Restarting/Starting all packag
es.
pfSense (pfSense) 2.3.4-RELEASE amd64 Wed May 03 15:13:29 CDT 2017
Bootup complete

FreeBSD/amd64 (pfSense.localdomain) (ttyv0)

*** Welcome to pfSense 2.3.4-RELEASE (amd64 full-install) on pfSense ***

 WAN (wan)       -> em0        -> v4/DHCP4: 10.0.2.15/24
 LAN (lan)       -> em1        -> v4: 192.168.1.1/24

 0) Logout (SSH only)                  9) pfTop
 1) Assign Interfaces                 10) Filter Logs
 2) Set interface(s) IP address       11) Restart webConfigurator
 3) Reset webConfigurator password    12) PHP shell + pfSense tools
 4) Reset to factory defaults         13) Update from console
 5) Reboot system                     14) Enable Secure Shell (sshd)
 6) Halt system                       15) Restore recent configuration
 7) Ping host                         16) Restart PHP-FPM
 8) Shell

Enter an option: █
```

using one on your home network, to the same value. You can also set your preferred network DNS servers here. Keep the bottom box checked if you would like pfSense to pull these from your ISP, or fill in the boxes and uncheck the box if you would prefer to use, for example, Google's super-fast public DNS servers, which are located at 8.8.8.8 and 8.8.4.4. Hit "Next" to select a time server for your network (although the default is just fine), and set your time zone.

›› The next screen is, at first glance, quite intimidating, although it's likely you won't have to touch much of it, unless your ISP is particularly harsh about its hardware restrictions. You'll likely be able to leave "DHCP" selected, scroll to the bottom, and move on. Leave the IP address as is, then set your admin password. Hit "Reload," and pfSense is all set up.

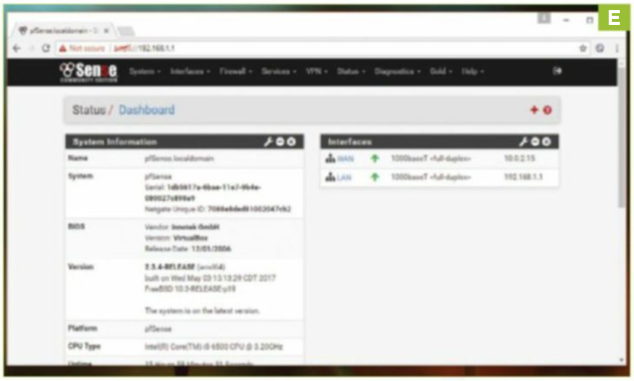
7 ADDING WI-FI

If all has gone well, you don't need to do anything else to pfSense to enjoy its benefits. It's now working as a firewall, traffic logger, and DHCP server, meaning it takes responsibility for handing out IP addresses to machines on your local network, and batting away traffic from sources that aren't welcome. The DHCP aspect can cause problems if you want to use Wi-Fi, because your router will likely put up a fight and try to push its own DHCP agenda, so that's the next step. Switch on your Wi-Fi router (though leave it free of network connections for now), and head to its settings screen.

›› The process is going to be different for every router, but you need to switch off just about everything, from DHCP to firewall. When you're satisfied that you've properly neutered the hardware, you can connect it to your pfSense box, plugging the LAN Ethernet cable into one of its client ports—not the Internet port, as you might presume. Connect to it via Wi-Fi, and you should see that you're online.

8 SEE IT ALL

Open a browser and head back to the pfSense settings screen, via the same IP address we used earlier. The initial dashboard [Image E] is a good place to see what it's currently up to, but there's not a huge amount on display by default, just a profile of your hardware and system resources, and information on its network connections. Click the red plus icon at the top of the screen to add more. We recommend adding the likes of "Services status," to see which extra services are running on top of



Name pfSense.localdomain

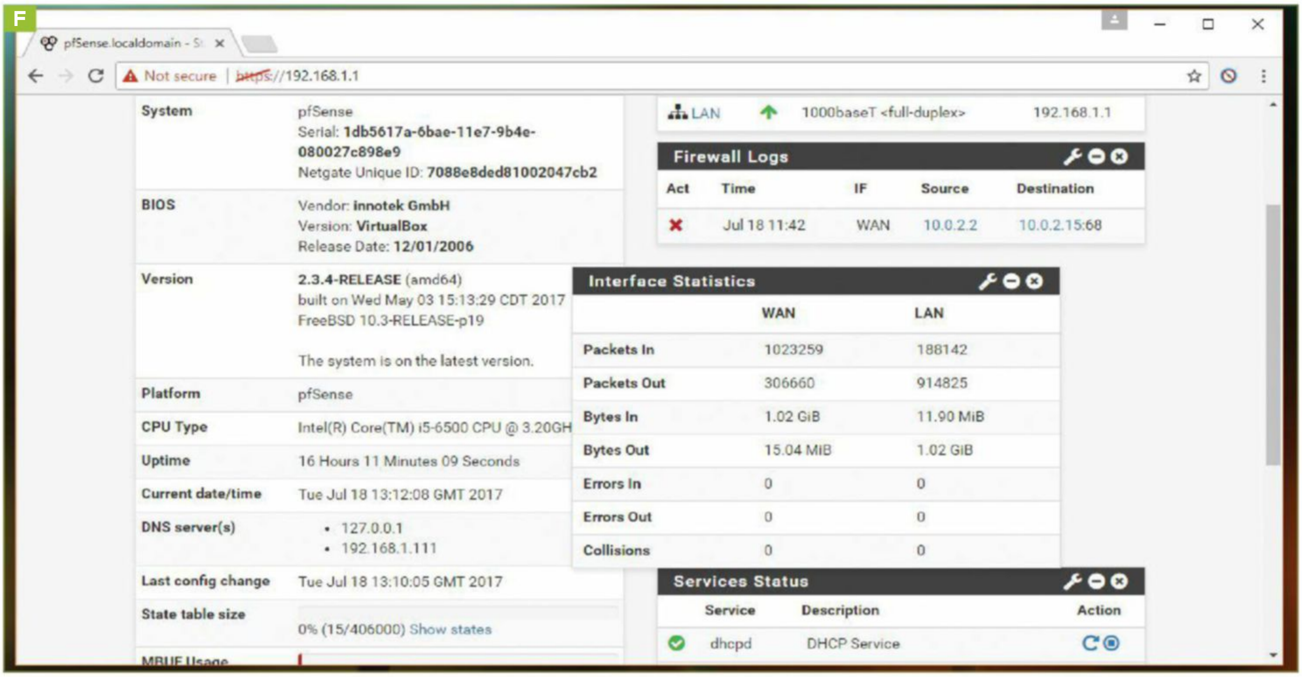
Version 2.3.4-RELEASE (amd64)
built on Wed May 03 15:13:29 CDT 2017
FreeBSD 10.3-RELEASE-p19

The system is on the latest version.

Platform pfSense

CPU Type Intel(R) Core(TM) i5-6500 CPU @ 3.20GHz

WAN 1000baseT <full-duplex> 10.0.2.15
LAN 1000baseT <full-duplex> 192.168.1.1



pfSense.localdomain - S

Not secure | ~~https~~://192.168.1.1

System	pfSense Serial: **1db5617a-6bae-11e7-9b4e-080027c898e9** Netgate Unique ID: **7088e8ded81002047cb2**
BIOS	Vendor: **innotek GmbH** Version: **VirtualBox** Release Date: **12/01/2006**
Version	**2.3.4-RELEASE** (amd64) built on Wed May 03 15:13:29 CDT 2017 FreeBSD 10.3-RELEASE-p19 The system is on the latest version.
Platform	pfSense
CPU Type	Intel(R) Core(TM) i5-6500 CPU @ 3.20GH
Uptime	16 Hours 11 Minutes 09 Seconds
Current date/time	Tue Jul 18 13:12:08 GMT 2017
DNS server(s)	• 127.0.0.1 • 192.168.1.111
Last config change	Tue Jul 18 13:10:05 GMT 2017
State table size	0% (15/406000) Show states
MBUF Usage	

LAN 1000baseT <full-duplex> 192.168.1.1

Firewall Logs

Act	Time	IF	Source	Destination
✗	Jul 18 11:42	WAN	10.0.2.2	10.0.2.15:68

Interface Statistics

	WAN	LAN
Packets In	1023259	188142
Packets Out	306660	914825
Bytes In	1.02 GiB	11.90 MiB
Bytes Out	15.04 MiB	1.02 GiB
Errors In	0	0
Errors Out	0	0
Collisions	0	0

Services Status

	Service	Description	Action
✓	dhcpd	DHCP Service	

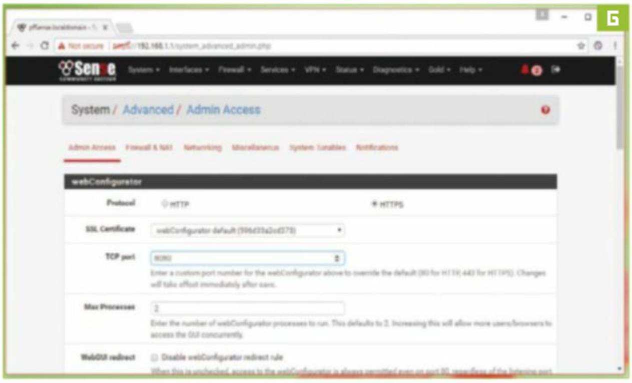
the firewall, and stop or restart them at will; "Interface statistics" for an at-a-glance view of how much traffic has been moving through your network; and "Firewall logs" to quickly see a worrying picture of just how many Chinese IP addresses have attempted to sniff around your network. You can configure each of these modules with the wrench icon, and drag their headers to reorder them on the page [**Image F**].

9

GETTING IN

Primarily, while it performs a host of other network functions, pfSense is a firewall. As such, it blocks access to itself from any machine outside of your local network, but we can use a rule, or exception, to ferry traffic to the right place. First, let's build in a little security, and place pfSense on a different port than the default, to prevent it being sniffed out by unscrupulous network invaders.

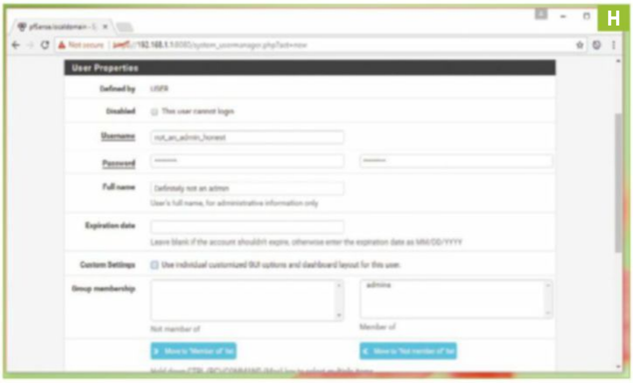
» Open "System / Advanced," make sure the "HTTPS" radio button is selected, and enter something along the lines of "8080" in the "TCP port" box near the top [**Image G**]. Scroll down and select the boxes to disable DNS rebinding checks and HTTP referrer enforcement, hit "Save," and you're automatically redirected to the pfSense admin pages via the new port—bear in mind that, from now on, you'll have to access it via this port, appending ":8080," for example, to the IP address.



10

OUTSIDE ACCESS

With our stealthy port in place, we can head to "Firewall / Rules." You'll see a couple of default entries, both of which are designed to prevent WAN access from addresses that really shouldn't be able to access your network anyway. "RFC 1918" refers to those IP addresses that are reserved for internal networks only (10.x.x.x, 192.168.x.x, and so on), and unassigned addresses are also, logically, banned. In fact, every direct connection to your network is currently verboten until you explicitly say otherwise. So, let's do that: Click either of the "Add" buttons, leave the default action as "pass," and set the destination address to "WAN address" with the drop-down menu. Set the port range to be from 8080 to 8080—essentially telling the firewall to only accept connections from that particular port—and you're now able to connect to pfSense by typing your WAN IP address, followed by a colon, and the appropriate port number, into any web browser. Check your dashboard page to find this address out; your ISP may occasionally change it, but not often. For a touch of extra security, set up a new user with admin rights in "System / User Manager" [**Image H**], then delete the original admin account to foil intruders targeting the most common usernames. ⏻



Operate LEDs and Motors With Your Pi

YOU'LL NEED THIS

RASPBERRY PI
Any 40-pin model of Pi, with Raspbian Pixel.

EXPLORER HAT PRO
Plus 1x LED, 1x 220 Ohm resistor, 1x push button switch, a DC motor, 6x male-to-male jumper wires, and a 10k potentiometer.

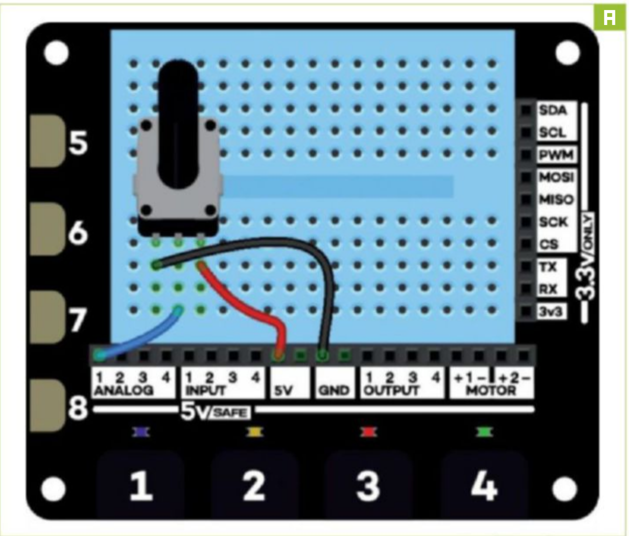
WE'VE GATHERED TOGETHER a quartet of 10-minute hacks that you can build using the Explorer HAT Pro for the Raspberry Pi. These four projects can be mixed together, and we'll be using the analog inputs with potentiometers, digital input/outputs with LEDs and buttons, and the H Bridge controller for operating DC motors with the board.

Before we power on the Raspberry Pi, we need to attach the Explorer HAT Pro to all 40 of the GPIO pins. The board should sit atop the Raspberry Pi, and match the outline of the Pi. Now power on your Raspberry Pi, and boot to the Pixel desktop. When ready, open a Terminal and enter the following command to install the Explorer HAT Pro libraries:

```
$ curl https://get.pimoroni.com/explorerhat | bash
```

Follow the installation instructions, and if prompted to reboot, do so, and return to the Pixel desktop. Now go to the main menu, and navigate to the "Programming" menu. Click "Python 3" to open the editor, then click "File → New" to begin. **–LES POUNDER**

A



1

TOGGLE THE LED

Here, we'll use the capacitive touch buttons (1–4) on the Explorer HAT Pro to trigger the built-in LEDs. With our blank document open, click "File → Save," and save the file as "Project1-LED-Toggle.py" before continuing. Remember to save often.

» We start the code by importing the "Explorer HAT Python3" library, then renaming it to "eh" so that it is easier to work with. We also import the "sleep" function from the "time" library:

```
import explorerhat as eh
from time import sleep
```

» Next, create an infinite loop to hold the code's main body:

```
while True:
```

» Then we set up a series of conditional tests, seeing if the capacitive touch buttons (1–4) have been pressed. For each button, we assign a color of LED that will be toggled on/off by pressing the button. We then add a delay to prevent an accidental double-tap:

```
    if eh.touch.one.is_pressed():
        eh.light.blue.toggle()
        sleep(0.1)
```

» The rest of the code follows the same pattern, but using "elif" to represent the other conditions to test:

```
    elif eh.touch.two.is_pressed():
        eh.light.yellow.toggle()
        sleep(0.1)
    elif eh.touch.three.is_pressed():
        eh.light.red.toggle()
        sleep(0.1)
    elif eh.touch.four.is_pressed():
        eh.light.green.toggle()
        sleep(0.1)
```

» Click "Run → Run Module" to run the code. Now press the 1–4 keys on the Explorer HAT Pro to trigger the LEDs.

2

THE BLINKING OBVIOUS

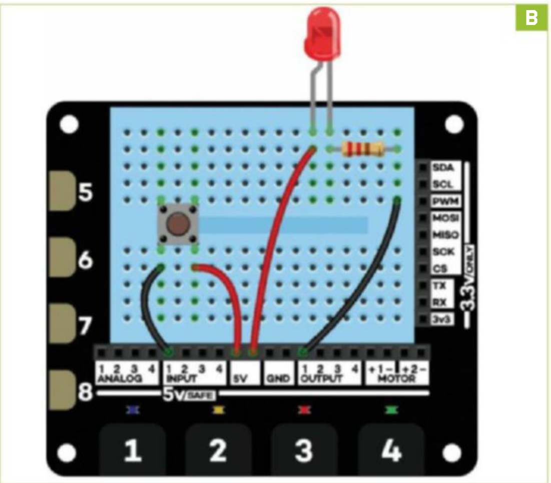
For this project, you need the potentiometer and three jumper wires. Connect as per the diagram [Image A]. Our potentiometer is connected to the ANALOG1 pin, and sends the voltage passing through the variable resistor as the dial is turned. At full voltage it's just over 5V.

» Create a new blank file called "Project2-Analog-Blink.py," and import the "Explorer HAT" library:

```
import explorerhat as eh
```

» Inside a "while True" loop, we now create two variables to read the voltage on ANALOG1, and store it for use:

B



```
while True:
    on = eh.analog.one.read()
    off = eh.analog.one.read()
```

» Next, we create a little hack that prevents the Python code crashing due to a divide by zero error based on the analog readings. If the value of our variables "on" and "off" ever reaches zero, we change their values to be 0.01:

```
    if on == 0 and off == 0:
        on = 0.01
        off = 0.01
```

» Our last line of code flashes the built-in LEDs (called blinking) with an on/off time that matches the voltage read at ANALOG1. This means a low voltage makes the LEDs flash faster, while a high voltage makes them flash slower.

```
    eh.light.blink(on,off)
```

» Click "Run → Run Module" to run the code. Now rotate the potentiometer's dial to change how fast the LEDs blink.

3

PUSH THE BUTTON

This project shows how the inputs and outputs of the Explorer HAT Pro work with external components, using a push button to toggle the built-in LEDs and a standard LED.

» Building this project requires the push button, an LED, a 220 Ohm resistor, and four jumper wires. The circuit is built on the breadboard as per the diagram shown below-left [**Image B**], with the button connected to 5V and INPUT1, the long leg of the LED connected to the 5V pin, and the short leg connected to OUTPUT1 via the resistor. The Explorer HAT OUTPUT pins are a path to Ground, and only activated when turned on.

» Create a new blank file called "Project3-Input-Output.py," import the "Explorer HAT" library, and then import the "sleep" function from the "time" library:

```
import explorerhat as eh
from time import sleep
```

» Now let's create a loop, and in there a conditional test, that will check to see whether the capacitive touch buttons (1–4) have been pressed. For button 1, it looks like this:

```
while True:
    if eh.touch.one.is_pressed():
```

» If that button has been pressed, we toggle the blue LED under button 1 to turn on/off. We also add a short sleep to prevent accidental double-taps:

```
        eh.light.blue.toggle()
        sleep(0.1)
```

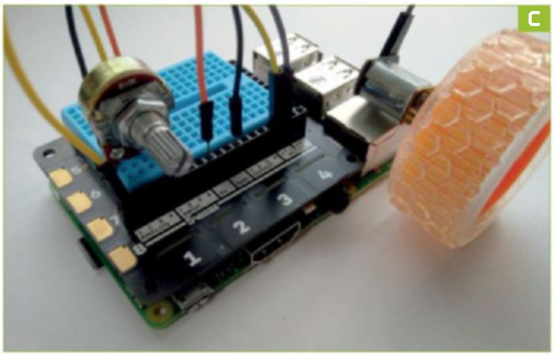
» We then create further conditional "else if" tests that will check to see whether buttons 2–4 have been pressed, and toggle the LED under each button to turn on:

```
    elif eh.touch.two.is_pressed():
        eh.light.yellow.toggle()
        sleep(0.1)
    elif eh.touch.three.is_pressed():
        eh.light.red.toggle()
        sleep(0.1)
    elif eh.touch.four.is_pressed():
        eh.light.green.toggle()
        sleep(0.1)
```

» Click "Run → Run Module" to run the code. Now press the capacitive buttons 1–4 to toggle the LEDs on and off.

4

GAIN MOTOR CONTROLS



For our final project, we need to connect up the potentiometer once again, and add a DC motor connected to MOTOR1 + and -. We're adding a simple speed controller for a DC motor using the potentiometer from Project 2 as an input. The Explorer HAT Pro comes with a DRV8833 motor controller that offers two motor channels, along with full forward/reverse control [**Image C**].

» Create a file called "Project4-Analog-Motor.py" before starting this project and importing the "Explorer HAT" library:

```
import explorerhat as eh
```

» We then create an infinite loop:

```
while True:
```

» Inside the loop, we create a variable called "speed," and in there we store the reading from ANALOG1, but we round the value to one decimal place for ease of use. We then multiply the value by 20 to give us a percentage value, which is then passed to the final line of code that controls the motor forward, and takes a percentage value to represent its speed:

```
    speed = (round(eh.analog.one.read()) * 20)
    eh.motor.one.forward(speed)
```

» With the code completed, click "Run → Run Module" to run the code. Now rotate the dial of your potentiometer to change how fast the motor spins. And now you've completed four projects with the Explorer HAT Pro!

EXPLORERS COME IN MANY PACKAGES...

In this tutorial, we're focusing on the Explorer HAT Pro, which is the top-of-the-line board. It comes with eight capacitive touch pads, four analog inputs, four digital inputs, and four outputs. We have a DRV8833 motor controller, and pins for I2C/SPI and serial connections. And we get a breadboard to prototype with.

The capacitive inputs 1–4 are best used with your hands, but if you wish to test the conductivity of a banana, for instance, or use either aluminum foil or copper tape to create larger circuits, then you can use inputs 5–8 with crocodile clips, and transform anything you like into a fun form of input. This is in much the same manner as the Makey Makey, a device that emulates a keyboard/mouse, and can turn conductive objects into forms of input.

The next option is the Explorer pHAT, which is designed for the Pi Zero, but will work with all 40-pin GPIO Raspberry Pis. The Explorer pHAT omits the capacitive touch interface, breadboard, LEDs, and the breakout for I2C—but it's half the price of the Pro version.

So, if you need an all-in-one solution for robots and analog sensors, the pHAT board is all you need. But if you want all the features for whatever your next project may be, perhaps the Pro board is more suited to you.

Minecraft Pi: Build a World

YOU'LL NEED THIS

RASPBERRY PI
This tutorial works on any model of Raspberry Pi.

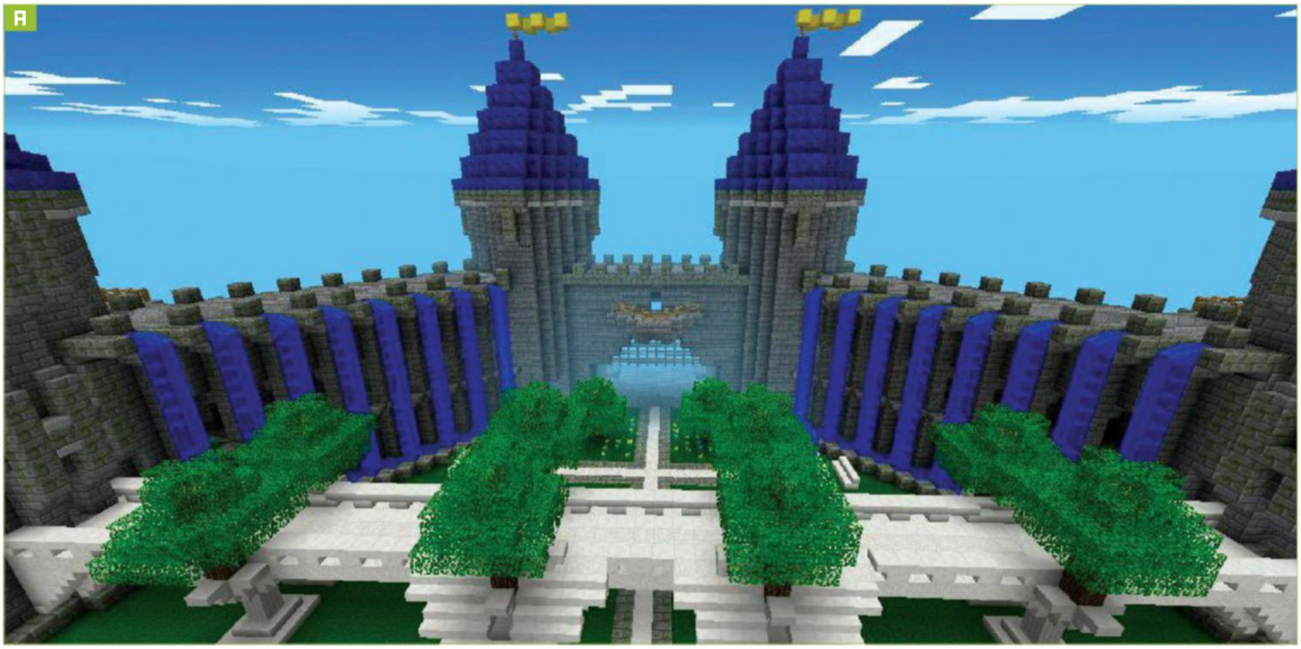
MINECRAFT: PI EDITION
Comes bundled with Raspbian, and includes a Python API.

BESIDES EMPOWERING A NEW GENERATION OF MAKERS, the Raspberry Pi has also established its merits as a gaming platform. Projects such as RetroPie, combined with the Pi's cheapness, mean that it's great for playing old classics. And even some new ones. Such as *Minecraft.*

In case you've been living under a rock since 2011, *Minecraft* is the best-selling computer game of all time. It's an open-world, sandbox affair, in which our hero, Steve, roams around a landscape made of voxels (blocks). Resources can be mined and crafted into other resources, so that Steve can build houses, farm crops, cook food, and fight enemies (all rendered in low-res splendor).

A special version, *Minecraft: Pi Edition,* was released in 2013, and has been bundled with Raspbian since 2014. This version is in some ways cut down, in the sense that there isn't any crafting or baddies, and nor is there any limit on the available resources. But it does have some features that aren't present in the full game, most notably a Python API for manipulating the world while a game is being played. Not having to worry about creatures trying to kill you or where your next meal is coming from makes it great for younger players, emphasizing the creative aspects of the game, and the Python API makes it an ideal platform for aspiring coders, young and old. –**JONNI BIDWELL**

A



1 FIRST STEPS

To get started, head to the menu, then "Games → Minecraft Pi." Choose "Single Player," then "New Game." The game window is offset from the app window behind it—ensure your cursor is parallel with the top of the app window, and hold down to reposition it.

›› Click "Start Game," followed by "Create New." Your new world now loads. Feel free to explore and build. The controls for the game are pretty simple, and are shown in the table to the right.

›› You can use the mouse to look around you. It can also be used to select items from the inventory. By default, you're holding a sword. Click blocks to destroy them. The sword can also be used to dig. If you select a block from your inventory, you can begin building. Use the right mouse button to place the block, or the left button to destroy it. With time, patience, and some coding to automate block placement, you can have your very own castle [**Image A**].

GAME CONTROLS

KEY	ACTION
W	Forward
A	Left
S	Backward
D	Right
E	Inventory
Space	Jump
Double-Space	Fly/Fall
Esc	Pause/Game menu
Tab	Release mouse cursor

INSTALL THE FULL MINECRAFT GAME ON THE PI 3

Open Terminal on your Raspberry Pi, and begin by installing some tools:

```
sudo apt-get -y install xcompmgr
libgl1-mesa-dri && sudo apt-get -y
install libalut0 libalut-dev && sudo
apt-get -y install mesa-utils
```

Next, we need to enable an experimental graphics driver. Run `sudo raspi-config` and scroll down to "Advanced Options." Press Return. Choose "AB – GL Driver" and enable it.

Now download the official *Minecraft* client with the following:

```
mkdir ~/Minecraft; mkdir ~/Minecraft/
Natives;
```

```
cd ~/Minecraft && wget https://
s3.amazonaws.com/Minecraft.
Download/launcher/Minecraft.jar
```

Launch it by running:

```
$ java -jar Minecraft.jar
```

Now you need to log in with your username and password. Next, click the "Profile Editor" tab, then click the box that's underneath "Version" to open up a new window. Find the drop-down menu named "Use Version," and choose "1.8.9." Next, click "Save Profile."

Click the "Play" button at the bottom to begin downloading the files. When the downloads are finished, you need to close the launcher and re-open Terminal.

Run the following commands:

```
$ cd ~/Minecraft/Natives &&
wget https://www.dropbox.com/
s/4oxcvz3ky7a3x6f/liblwjgl.so
```

```
$ wget https://www.dropbox.com/s/
m0r8e01jg2og36z/libopenal.so
```

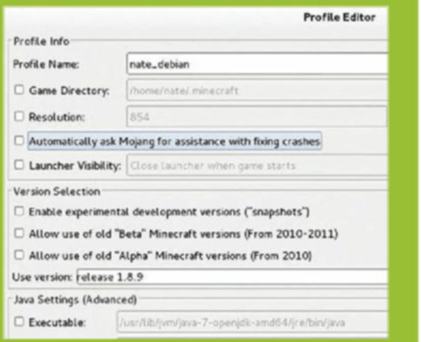
```
$ cd /home/pi/.minecraft/libraries/
org/lwjgl/lwjgl/lwjgl/2.9.4-
nightly-20150209 && rm lwjgl-2.9.4-
nightly-20150209.jar
```

```
$ wget https://www.dropbox.com/s/
mj15sz3bub4dmr6/lwjgl-2.9.4-
nightly-20150209.jar
```

```
$ cd ~/Minecraft/
```

```
$ wget https://www.dropbox.com/s/
jkhr58apwa7pt1w/run.sh
```

```
$ sudo chmod +x run.sh
```



Profile Name: nate_debian
☐ Game Directory: /home/nate/.minecraft
☐ Resolution: 854
☐ Automatically ask Mojang for assistance with fixing crashes
☐ Launcher Visibility: Close launcher when game starts
☐ Enable experimental development versions ("snapshots")
☐ Allow use of old "Beta" Minecraft versions (From 2010-2011)
☐ Allow use of old "Alpha" Minecraft versions (From 2010)
Use version: release 1.8.9
☐ Executable: /usr/lib/jvm/java-7-openjdk-amd64/jre/bin/java

Next, we need to make some changes to one of the files we've downloaded with the following:

```
$ sudo nano ~/Minecraft/run.sh
```

Scroll down with the arrows, and after the "=" enter your *Minecraft* personal details: email, username, and password. Press Ctrl-X when you're done, then press Y and Enter to confirm the changes.

To run *Minecraft* at any time, just enter the following command:

```
cd ~/Minecraft && ./run.sh
```

2

CODING BLOCKS

To start coding in *Minecraft: Pi Edition*, press the Tab key while it's running. Go to "Menu → Programing." Click "Python 3." Try to place the text boxes so they're next to one another.

›› You can type commands here to change the in-game world. Over time, you can also write scripts to automate tasks for you—for example, a script that places a stone block wherever you walk. So, let's reprogram the game to display a simple message. Type in the following commands, pressing Return after each one:

```
from mcpi.minecraft import Minecraft
mc = Minecraft.create()
mc.postToChat("Hello world, I'm playing Minecraft Pi!!!")
```

›› Press Return to display your first in-game message. Next, look at the top-left of the *Minecraft Pi* screen. You can see your X, Y, and Z co-ordinates. This is an excellent way to work out your location, as well as place blocks precisely.

›› You can use Python to summon any number of blocks of various materials. First, let's try placing a single gold block immediately behind you. Type in the following command:

```
x, y, z = mc.player.getPos()
```

›› You need to run the above command each time you move, to give the game your updated co-ordinates. Press Return, then type:

```
mc.setBlock(x+1, y, z, 41)
```

›› The number "41" at the end of the last command represents the ID number for gold. Each block or item in the game has a unique ID. If you know the ID of a particular type of block, assign it a name to make it easier to remember. For example:

```
gold=41
```

›› Press Return, then run these commands to create a giant 10x10x10 cube of solid gold [**Image B**]:

```
x, y, z = mc.player.getPos()
mc.setBlocks(x+1, y+1, z+1, x+11, y+11, z+11, gold)
```

›› This is just a small selection of commands that can be run on *Minecraft Pi*. It's also possible to form complex shapes, teleport the player, and even drop blocks as you move around. For a complete list of commands that you can run in *Minecraft: Pi Edition*, as well as the ID numbers for each type of block, head on over to www.stuffaboutcode.com/p/minecraft-api-reference.html.

3

AVOIDING THE MINEFIELDS

As we've discussed, *Minecraft Pi* is very similar to the *Pocket* edition of *Minecraft*, which can be played on handheld devices such as Android phones and iPhones. It can't interact with people using the official *Minecraft* client. According to reports on the Mojang website, it appears the client hasn't been updated in a while, but if you simply want to make simple structures and learn to code, without the extra features of the full *Minecraft* client, it's ideal.

›› Although we've seen it's possible to get the full version of *Minecraft 1.8.9* running on a Raspberry Pi 3 (see the boxout, above), the method isn't officially supported by Mojang. This means that you're likely to see reduced performance compared to a regular desktop machine, including glitches and crashes some of the time.

›› The experimental graphics driver that has to be enabled on the Raspberry Pi to use the full version of *Minecraft* stops the official *Minecraft Pi* client from working, but you can disable it again by running `sudo raspi-config`, and then rebooting the machine.

›› Neither version of *Minecraft* plays particularly well if you're accessing the Pi over VNC, so it's best to play it directly.

›› If you wish to play the full version of *Minecraft*, you do need to purchase an account from Mojang (currently priced at $26.95). If you now have the *Minecraft* bug and want to take it further, read on for details of how to set up your own *Minecraft* server on the Pi, and build your own digital world block by block.

4

MINECRAFT SERVER

On the previous pages, we discussed how to play *Minecraft* directly on the Pi, partly for fun and partly as an introduction to programing with Python. This part of the tutorial concerns installing the *Minecraft* server software on the Raspberry Pi 3. This enables others running the *Minecraft* client on their computers to connect to your own online world and play free from thieves and "griefers."

» *Minecraft* runs in Java, which is pre-installed in the latest version of Raspbian, meaning it's easier than ever to set up a server. The server has fairly low requirements, but for best performance, we recommend using a Raspberry Pi 2 or 3. With your Pi in hand and a fresh install of Raspbian, connect to it via SSH. Note that the default username and password are "raspberry" and "pi," respectively. Note your Pi's IP address—you'll need it later.

» Next, create a directory for *Minecraft*, and open it with the following command:

```
$ mkdir minecraft && cd minecraft
```

» Then download the latest version of SpigotMC, a highly customizable and lightweight version of Minecraft Server:

```
$ wget https://hub.spigotmc.org/jenkins/job/BuildTools/
lastSuccessfulBuild/artifact/target/BuildTools.jar
```

» Next, tell the Pi to start building the server tools:

```
$ java -jar BuildTools.jar
```

» Once the process is complete, you'll see a message stating "Saved as spigot-1.x.x.jar," where "1.x.x" is the current version number of Spigot that was downloaded (1.11.2 at the time of writing). Next, start the *Minecraft* server with:

```
$ java -jar -Xms512M -Xmx1008M spigot-1.x.x.jar nogui
```

» Again, substitute "1.x.x" with the version number of Spigot. The program tells you that you need to agree to the EULA in order to run the server. To do this, type the following command:

```
$ nano eula.txt
```

» Scroll down with your arrow keys and delete the word `false` . Replace it with `TRUE` . Press Ctrl-X, then Y, and Return to save your changes.

» Start the server software again with the same command as before:

```
$ java -jar -Xms512M -Xmx1008M spigot-1.x.x.jar nogui
```

» You'll see a message stating "Loading Libraries, please wait…" and some basic information about the game. Note that the default game mode is Survival, and you then see the spawn area loading slowly as a percentage. This may restart a couple of times as various levels are spawned. You'll see a message stating "Done!" once the process is complete.

» Now it's time to test your server. Go to a computer with the *Minecraft* client installed, and start the program. On the main screen, choose "Multiplayer." Next, click "Add Server." Click the box marked "Server Name," and type a name of your choice—for example, "Pi Minecraft Server." Click the box marked "Server Address," and enter the IP address of your Pi. Click "Done" when complete. You should now see the *Minecraft* server listed.

» Hover your mouse over it, and click the blue "Play" button. When the game loads, feel free to wander around a little, and even work through your anger issues by smashing a few blocks to make sure the game responds well. Once you're satisfied, close the *Minecraft* window, and return to your SSH client, which is still connected to the Pi. Type `stop` for the time being to stop the server.

» You can type `stop` at any time to halt the server if, for instance, you need to make any changes. In future, if you wish to run the server software, connect to the Pi via SSH, then use the following command:

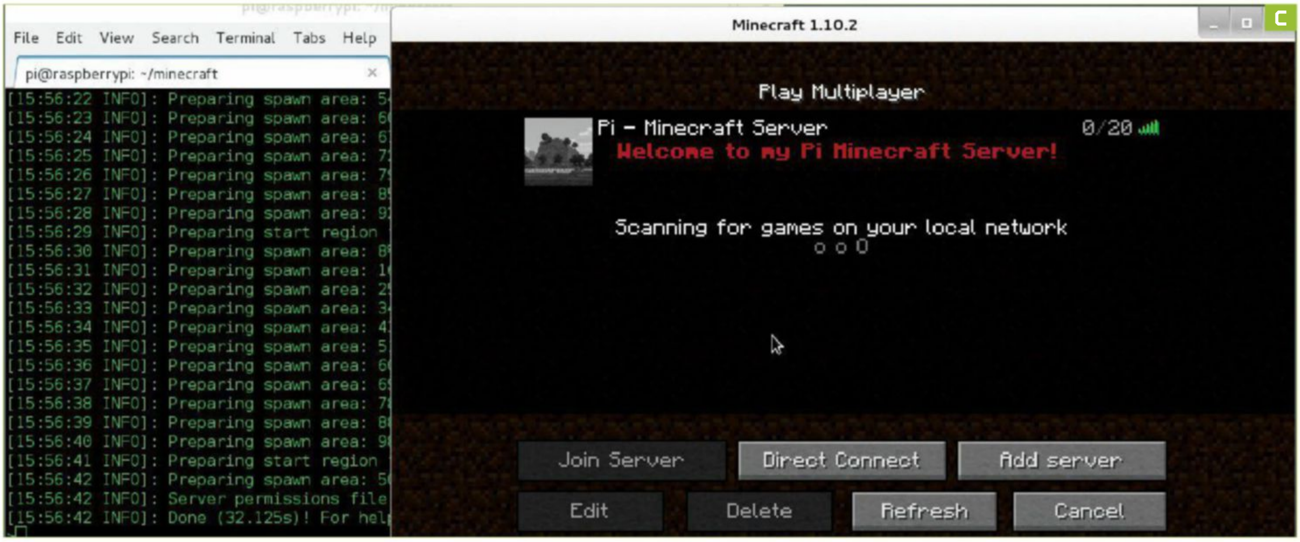
```
$ cd ~/minecraft && java -jar -Xms512M -Xmx1008M
spigot-1.x.x.jar nogui
```

» Again, replace "1.x.x" with the actual version number of Spigot you currently have installed. If you're unsure of this, type the command `cd ~/minecraft && ls` to view the contents of the "minecraft" folder—you can then see the version of spigot-1.x.x.jar in there.

5

BASIC SETTINGS

Once the server is up and running, it's time to look at how you can tweak some of the settings. The



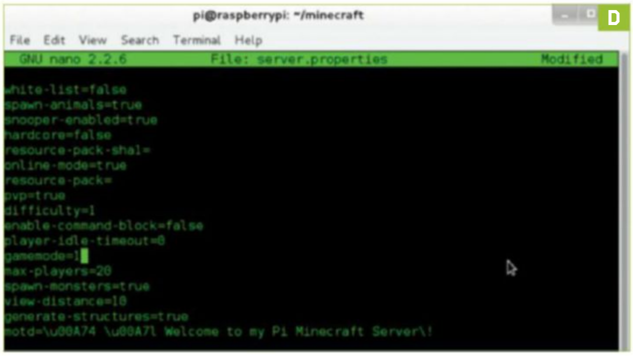
```
[15:56:22 INFO]: Preparing spawn area: 5
[15:56:23 INFO]: Preparing spawn area: 6
[15:56:24 INFO]: Preparing spawn area: 6
[15:56:25 INFO]: Preparing spawn area: 7
[15:56:26 INFO]: Preparing spawn area: 7
[15:56:27 INFO]: Preparing spawn area: 8
[15:56:28 INFO]: Preparing spawn area: 9
[15:56:29 INFO]: Preparing start region
[15:56:30 INFO]: Preparing spawn area: 8
[15:56:31 INFO]: Preparing spawn area: 1
[15:56:32 INFO]: Preparing spawn area: 2
[15:56:33 INFO]: Preparing spawn area: 3
[15:56:34 INFO]: Preparing spawn area: 4
[15:56:35 INFO]: Preparing spawn area: 5
[15:56:36 INFO]: Preparing spawn area: 6
[15:56:37 INFO]: Preparing spawn area: 6
[15:56:38 INFO]: Preparing spawn area: 7
[15:56:39 INFO]: Preparing spawn area: 8
[15:56:40 INFO]: Preparing spawn area: 9
[15:56:41 INFO]: Preparing start region
[15:56:42 INFO]: Preparing spawn area: 5
[15:56:42 INFO]: Server permissions file
[15:56:42 INFO]: Done (32.125s)! For hel
```

Play Multiplayer

Pi - Minecraft Server 0/20

Welcome to my Pi Minecraft Server!

Scanning for games on your local network



D

```
pi@raspberrypi: ~/minecraft
  GNU nano 2.2.6            File: server.properties                  Modified

white-list=false
spawn-animals=true
snooper-enabled=true
hardcore=false
resource-pack-sha1=
online-mode=true
resource-pack=
pvp=true
difficulty=1
enable-command-block=false
player-idle-timeout=0
gamemode=1
max-players=20
spawn-monsters=true
view-distance=10
generate-structures=true
motd=\u00A74 \u00A7l Welcome to my Pi Minecraft Server\!
```

basic settings are contained in a file named "server.properties." You can view and edit this file by running the command:

```
$ cd ~/minecraft && nano server.properties
```

» If you're intent on fine-tuning your *Minecraft* world, visit http://minecraft.gamepedia.com/server.properties to view all values for all potential settings. For now, we're just making some basic changes. Scroll to the very bottom of the file to the value `motd=` using your cursor keys. This is simply the message that appears when you first connect to the *Minecraft* server. By default, this simply says "A Minecraft server."

» Delete the line of text, and replace it with the following cheery message [**Image C**]:

```
motd=\u00A74 \u00A7l Welcome to my Pi Minecraft Server\!
```

» Another change you may want to make to the server—especially for people new to *Minecraft*—is to change from Survival Mode to Creative. Creative Mode allows for an infinite amount of building materials. Players also don't become hungry or lose energy, so are free to start making their constructs right away.

» Scroll up to `gamemode=0` and change the 0 to 1 to do this. Make sure to change `force-gamemode=false` to `true`, as well, to be certain that everyone who logs on in the future will also be in Creative Mode.

» If you're determined to stay in Survival Mode, but want to start off slowly, consider changing `spawn-monsters=true` to `false`. You can also change the game's difficulty by changing `difficulty=1` to a value between 0 and 3, with zero being the easiest difficulty level.

» When you are satisfied with the changes you've made, hit Ctrl-X, then Y, then Return to save your changes and boot the server.

6 ADVANCED TWEAKS

As you become more comfortable with *Minecraft*, or if you're already an experienced player, you may find the basic configuration options in "server.properties" [**Image D**] limiting.

» This is where SpigotMC really comes into its own, with an advanced configuration file. There's a number of tweaks to improve your *Minecraft* experience. Simply stop the server, then run the following command:

```
$ cd ~/minecraft && nano spigot.yml
```

» By way of an example of how finely tuned Spigot is, scroll down to where it says `zombie-aggressive-towards-villager: true` and change it to `false`. This setting determines whether or not zombies attempt to kill *Minecraft* villagers. The Pi requires fewer AI resources for "friendly" zombies, so this may speed up your server.

» A complete list of the various settings that can be changed in Spigot, along with full descriptions of what they do, can be found at www.spigotmc.org/wiki/spigot-configuration.

7 SERVER SLOWDOWN

Your configuration may now be tweaked to your heart's content, but as more players join, and more complex structures are created, you may find *Minecraft* slowing down. One way to make sure there is plenty of free space is to move the "minecraft" folder to an external drive. The syntax of the necessary command is `$ sudo mv ~/minecraft /media/pi/MYUSB`, where `MYUSB` is the name of your USB stick.

» Bear in mind that the above commands for running the software include the `cd` command, which refers to the "minecraft" directory in the "home" folder, so make sure to modify the commands accordingly— `cd ~/minecraft` becomes `cd /media/pi/MYUSB/minecraft`, for example.

» If you're still having trouble, try starting the server with the following command which, without going into technical details, instructs Java to make better use of your processor:

```
$ cd ~/minecraft && java -jar -Xms512M -Xmx1008M
-XX:+UseConcMarkSweepGC -XX:+UseParNewGC
-XX:+CMSIncrementalPacing -XX:ParallelGCThreads=2
-XX:+AggressiveOpts -jar spigot-1.x.x.jar nogui
```

» For even better performance, consider editing the "server.properties" file once again, this time reducing `view-distance` from 10 to 5. This determines how much of the map has to load as you move around. You can also alter `max-players` to change the number of people who can be logged in at the same time. ⏻

GOING GLOBAL WITH MINECRAFT

Port Forwarding Guides for Minecraft Server

Please select your router's manufacturer from the list of manufactures below.

If you do not feel like figuring out how to forward ports manually, we have a simple software solution called PFConfig that can forward your ports for you automatically. We offer complete support for our product and will help you get your ports forwarded.

Do you want your port forwarded right now?

Our software makes it easy.

Created and Supported by Portforward.com

This tutorial explains how to set up *Minecraft* on your local network, meaning anyone who wants to play needs to be connected to it. However, you may wish to allow others to join your server over the Internet.

First, you need to assign your Pi a permanent IP address on your network by editing `/etc/network/interfaces`. Next, use a feature known as port forwarding on your router to forward incoming traffic from the outside Internet to the Pi itself.

Because each router is different, it's best to check the specific steps to do this with your router manufacturer, or enlist a more technically able friend. In either case, say that you need to open port 25565 for both TCP and UDP. You also need your router's external IP address, which you can get by visiting www.whatismyip.com.

The Port Forward website has multiple guides for setting up port forwarding: http://portforward.com/english/applications/port_forwarding/Minecraft_Server.

Your ISP may change the IP address of your router from time to time, which could cause difficulties for people playing. You can pay to rent a static IP from your ISP, or get a free one from a service such as www.noip.com.

Create Realistic T-Shirt Graphics

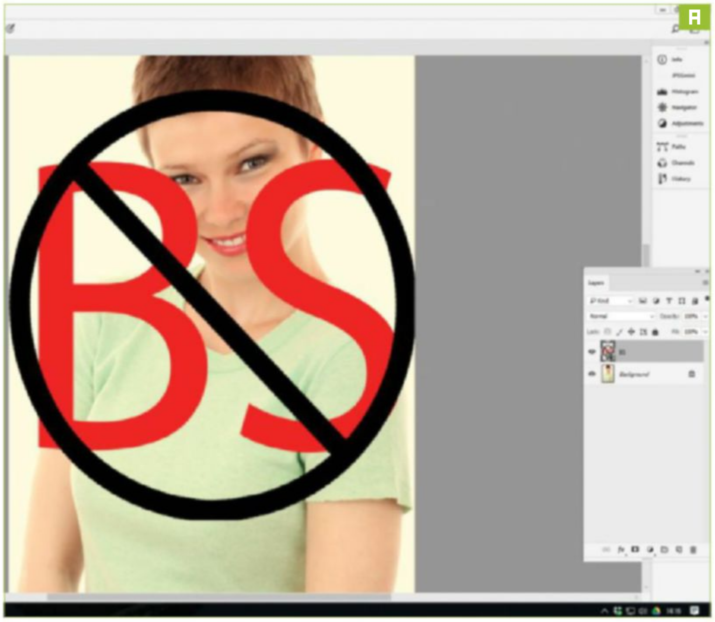
YOU'LL NEED THIS

ADOBE PHOTOSHOP
Subscribe to various packages at www.adobe.com.

A LOGO
Plus, an image of someone wearing a T-shirt.

GETTING YOUR LOGO on to a T-shirt to be worn by the bright young things of our new American century is a great way to build a brand. But how to get them to wear it? Stick it on your shop front, of course. And you don't have to go to the trouble of making a T-shirt and paying a model to wear it for you. Using Photoshop, you can make your logo fit every wrinkle of the fabric caused by your model's insouciant slouch, and reflect every shadow cast by the lighting. We're using Photoshop CC, but it's a fairly straightforward process, involving layers and blending, so could potentially be done in other apps, such as Affinity Photo or the cut-down Elements release of Photoshop, too.

When you're done, no one will be able to tell that you didn't photograph a real shirt. Of course, first you're going to need a logo, and that's an entirely different forest full of bears... For now let's just stick to the T-shirt. –IAN EVENDEN



1 GET YOUR LOGO ON A T-SHIRT

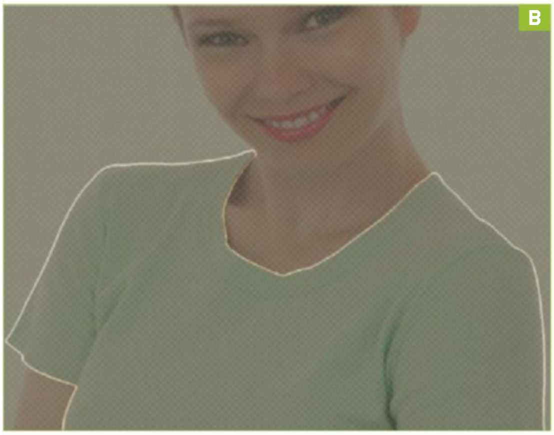
So first, create your logo. We've drawn a quick "Minimum BS" logo in Photoshop, really taking advantage of the program's power, but obviously yours will be much better. We also tried it with a line of text—a perfectly workable choice if you can't draw. Place the logo on your T-shirt image in any way that preserves its transparent background, so save it out as a PNG and place it, or export the layers as a Smart Object, and import this into your composition file [**Image A**]. Make sure it's too big, so you can shrink it into place—it's always better to do this rather than subsequently making something bigger, to retain quality. Once it's there, use "Edit → Free Transform" to shrink the logo, and rotate it into position if needs be. If your model is at a slight angle to the camera, you may need to add a bit of perspective by using "Edit → Transform → Perspective" or "Skew," to make the part of the logo nearest the camera slightly larger. You can duplicate and then hide its layer before you start, making a backup copy in case you later decide you've made it too small. If you're using text as your logo, leave it in vector form until you've finished resizing it, before hitting "Rasterize Layer," as this keeps the quality high.

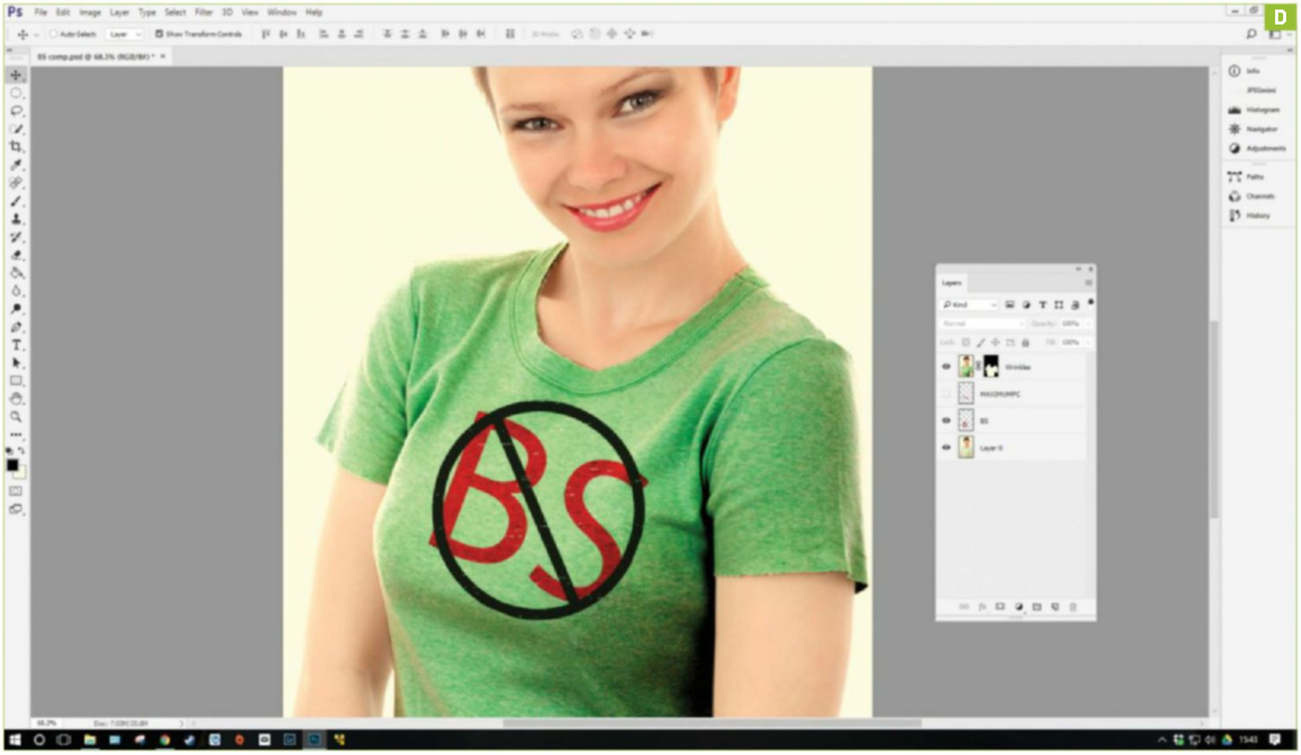
2 COPY THE SHIRT

We're going to need a copy of the T-shirt, too, so select it to separate it from the rest of the image. There are a few ways to do this, especially if it's a simple area of flat color with high-contrast edges: You can use the Quick Selection or Magic Wand tools; you can run the Magnetic Lasso around the edge; or if, like us, you were first shown how to do this using Photoshop 5 by someone who had been trained on even older software, you can use the Pen tool, and lay a vector path around the edge, before loading it as a selection from the Paths palette. This has the advantage that you can save the path and use it as a backup, but there's nothing wrong with doing it the other ways if you prefer.

3 TIDY UP THE SELECTION

To clean up your selection, it was once common to use "Refine Edge." However, this useful tool has vanished in the latest release of Photoshop CC, replaced on the "Select" menu by "Select and Mask" [**Image B**]. Play with this until you're happy with the selection. One minor benefit of using the Pen tool to create a selection is that you get long, smooth curves, rather than a lot of tricky switchbacks, so there's less to smooth out. When you're happy with your selection, save it, make sure the T-shirt layer is selected, and not any imported logo layers, and copy the selection to a new layer ("Layer → New → Layer





via Copy"). Add a Layer Mask by making sure you have the right layer selected, then hitting the button at the bottom of the Layers palette that looks like a black rectangle with a white circle in it. This allows the rest of the image to show through, only applying the effect inside the selection.

4

SHADOW PLAY

This new layer is going to become the wrinkles. Use Levels ("Image → Adjustments → Levels") to darken the dark bits and lighten the light bits, by moving the outer triangles toward the highest part of the histogram. You want an exaggerated, high-contrast end result. Avoid clipping—the mushing of shadows or highlights to pure black or white respectively—as much as you can, because this would mean your shadows appear abruptly, rather than gradually fading to their darkest.

5

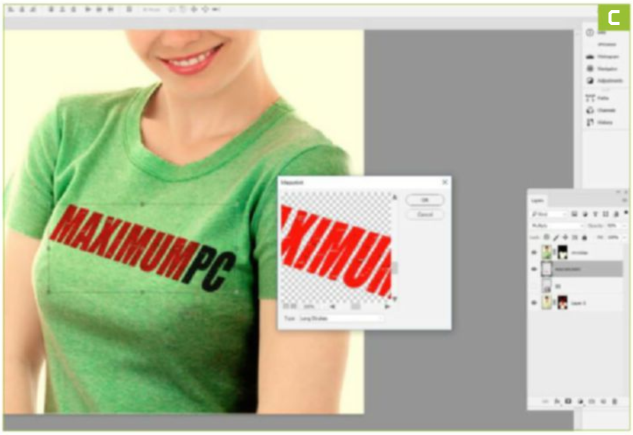
ADD SOME REALISM

Make sure this wrinkle map layer is on the top of the stack in the Layers palette, followed by your logo, then the base model-in-shirt layer. Change the blend mode of the topmost (wrinkle map) layer to "Multiply"—this darkens the colors below it, so your T-shirt becomes darker, but it allows the texture of the fabric to show through. Leave the logo layer on "Normal" blend mode, but reduce its opacity to around 85 percent. This helps blend it into the cloth background, making it look printed, rather than just floating in front. We've also added a bit of grungy noise to ours, using the Mezzotint filter ("Filter → Pixellate → Mezzotint") [**Image C**], so it looks as though the transfer has started to peel slightly, but that's not a necessary step if your composition isn't going to be looked at very closely. If you've used a text layer, you need to rasterize it before doing this.

6

PUT IT ON DISPLAY

When you're happy with the way it looks, finish up by flattening the layers, and exporting as a JPEG or PNG file, ready for use on a website [**Image D**]. ⏻



LINK TO THE SMART

A Linked Smart Object is a layer that contains image data from an external source, such as another Photoshop or Illustrator file. When the source file is updated, the Linked Smart Object is updated, too, saving you the trouble of changing your T-shirt graphics every time the bored designer tweaks his logos. You can also perform transforms on these layers, skewing, growing, and shrinking them, without worrying about losing quality, because the original data is always accessible in the linked file, rather than being thrown away when you commit to a transform. Linked vector files also remain vector files, rather than being rasterized on import, so can be manipulated without fear of pixellation.

BUILD IT

ZAK STOREY, REVIEWS EDITOR

Liquid-Cooled Ryzen Gaming

An (almost) mid-range build under ice

LENGTH OF TIME: **5–6 HOURS**

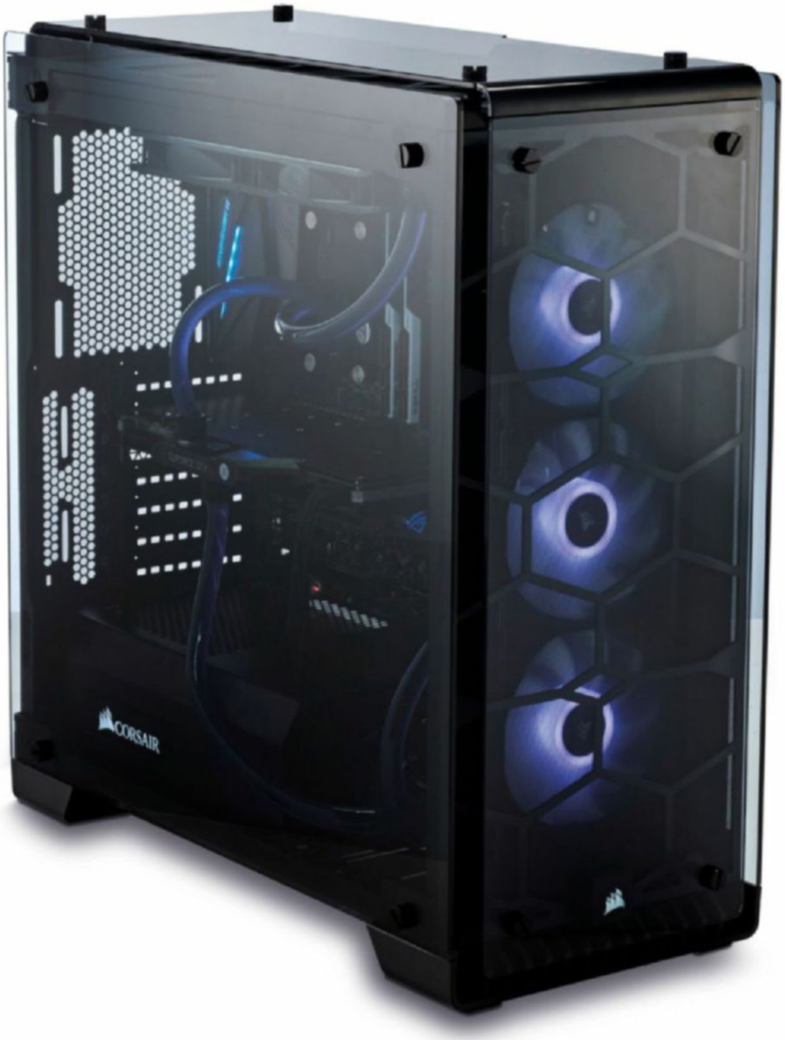
LEVEL OF DIFFICULTY: **MEDIUM**

THE CONCEPT

WELL, THIS WAS FUN. As we explained in our liquid cooling feature (pg. 36), EKWB sent us one of its latest Fluid Gaming Kits. In fact, it sent us two: a standard 240mm CPU-only loop, and one with an additional GPU block. Naturally, we gravitated to the latter, not because it's pricier than its $160 kin, but because it's the more intriguing solution. We're used to cooling processors off a single 240mm radiator, but adding a GPU to the loop (literally), a part that can pack some serious heat, just seemed ludicrous.

We made the decision to go with Ryzen at the very last minute. We've been wanting to revisit the platform for some time now. As both BIOS and micro-code have developed over the past few months, the platform has gone from being a touch sketchy to a well-equipped all-rounder, filled to the brim with serious computational performance. Overclocking has always been its limitation, though, with most parts only ever capable of boosting the clock speed by an additional 200–300MHz. And it's not heat that limits the plucky processor, but silicon, with most, if not all, Ryzen chips being limited to around the 4GHz mark, Threadripper included.

That said, contrary to popular belief, it's not a hot part. Once you strip off the ridiculous +20 C offset AMD imposes on the internal temperature monitoring, it's actually cooler than a lot of Intel's latest Kaby Lake parts. Weird, huh?



DISSECTING THE BEAST

IN OUR CONTINUED ATTEMPTS to annoy our photographers, we decided to go with the shiniest, most reflective case in the world, Corsair's Crystal 570X, with its included RGB fans. It's a dash gaudy, a fingerprint magnet, and lacks a lot of the home comforts we expect from a case at this price point. Still, the last laugh was over us, as it's not the friendliest of liquid-cooling chassis. At least, not if you're planning on mounting a reservoir anywhere.

Case aside, the core components are fairly high-end. It's not a cheap build, but not ridiculous either, featuring a GeForce GTX 1070, 32GB of DDR4, and Asus's king of X370 mobos, the Crosshair VI Hero. And it all went together quite nicely. That G.Skill memory comes packing 16GB per stick at an impressive 3,200MHz, which is apparently the optimum for Ryzen parts, as the infinity fabric connecting all the core complexes runs at the same frequency as the memory, which seems odd, but we'll bite.

The GPU is the kingpin of this build. The 1070 is a stunning sweet spot of a card. Perfect for 1440p and high refresh 1080p, if you ramp up the power target, and throw a +200MHz clock on the core, it's easy to get an extra 10–15 percent performance from it.

Unfortunately, ours was a reference card, and is currently unavailable—however, the cheapest GTX 1070 you can buy on Newegg features a reference PCB, which is fully compatible with EK's latest aluminum waterblock.

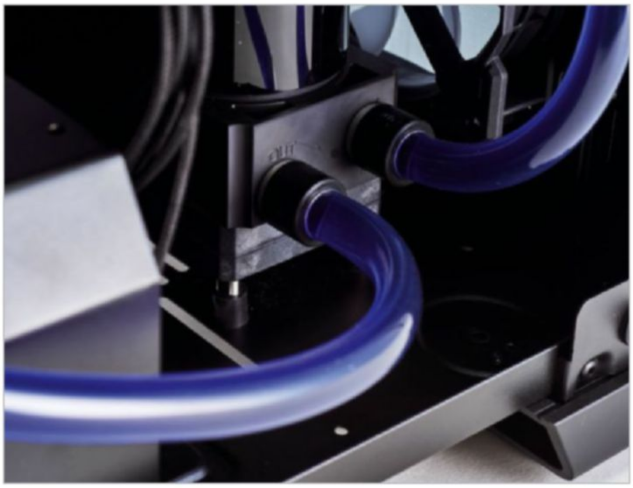
INGREDIENTS

PART		STREET PRICE
Case	Corsair Crystal 570X RGB TG	$180
Motherboard	Asus ROG Crosshair VI Hero	$270
CPU	Ryzen 7 1800X	$460
Memory	32GB (2x 16GB) G.Skill TridentZ Series 3,200MT/s	$288
GPU	EVGA GeForce GTX 1070	$440
PSU	BitFenix Fury Alchemy 750W Plus Gold	$223
Storage	275GB Crucial MX300 2.5-inch SSD	$100
Cooling	EKWB Fluid Gaming Kit A240G	$260
Operating System	Windows 10 Home	$100
Total		$2,321

1

MOUNTING MAYHEM

BY DEFAULT, EK'S Fluid Gaming Kit includes a bracket that you can install the pump/res on to easily enough—typically, you would run the fans externally of the radiator, then attach it to the internal side of the rad, before then mounting the pump that way. However, we decided to mount ours to the floor. Unfortunately, Corsair's Crystal 570X case lacks any mounting points, so we grabbed the old Dremel, and drilled a couple of mounting points in the floor. To do this, you need to remove the feet from the case, but once in, it's certainly not going anywhere.



2

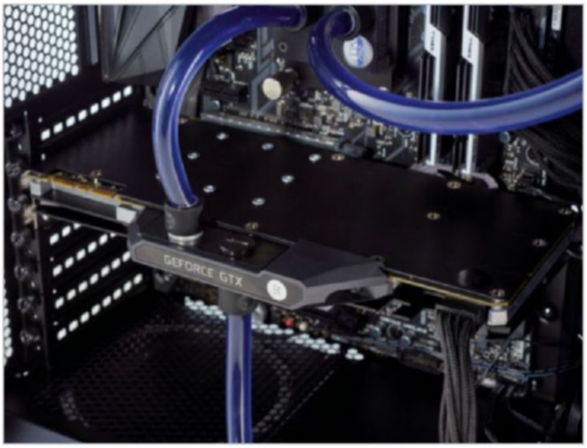
ALMOST COVERED

OH CORSAIR, what were you thinking? We absolutely love the Crystal 570X, but the lack of a full PSU cover is genuinely depressing. It wouldn't be so bad if it weren't for the fact that the front (RGB? Yep!) LED logo cable runs haphazardly from the front, hooked under a small metal clip, and into that gaping chasm of a PSU cover. In fact, we're kinda glad the reservoir is there just to hide it. Fortunately, Corsair has listened to the complaints of all us pesky journos and consumers, and is introducing a variant with a full PSU cover.

3

ALUMINUM ARDOR

THERE'S SOMETHING ABOUT these aluminum blocks we just love. Whether it's the subtle Nvidia font and branding next to the EK logo, or the underside that looks simply stunning, or the fact that EK has somehow managed to bundle in a backplate as well, they're just awesome. Installing the block is a very similar affair to any other GPU block, so once you've nailed this one, you'll be more than capable of installing one on anything from a RX 480 to a Titan Xp. One thing we do wish, though, is that those screws were black, rather than silver—but, hey, you can't always get what you want.



4

A TALE OF TUBES

SOFT TUBING IS SIMULTANEOUSLY a joy to work with and a nightmare. Although you don't have to bend it, and it does allow you to swap out components a hell of a lot more easily than its hardline equivalent, attaching it to the barb parts of the fitting is a challenge, particularly with the Fluid Gaming Kits. To make life easier, we recommend getting a bowl of hot water, immersing the end of each length of tubing you've cut to size and want to install on a fitting, then using a pair of needle-nose pliers to stretch the tubing. Then just wiggle it on to the barb.

5

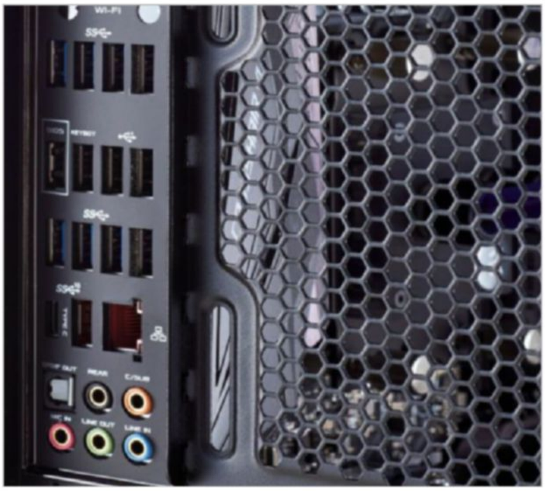
LENGTH MATTERS

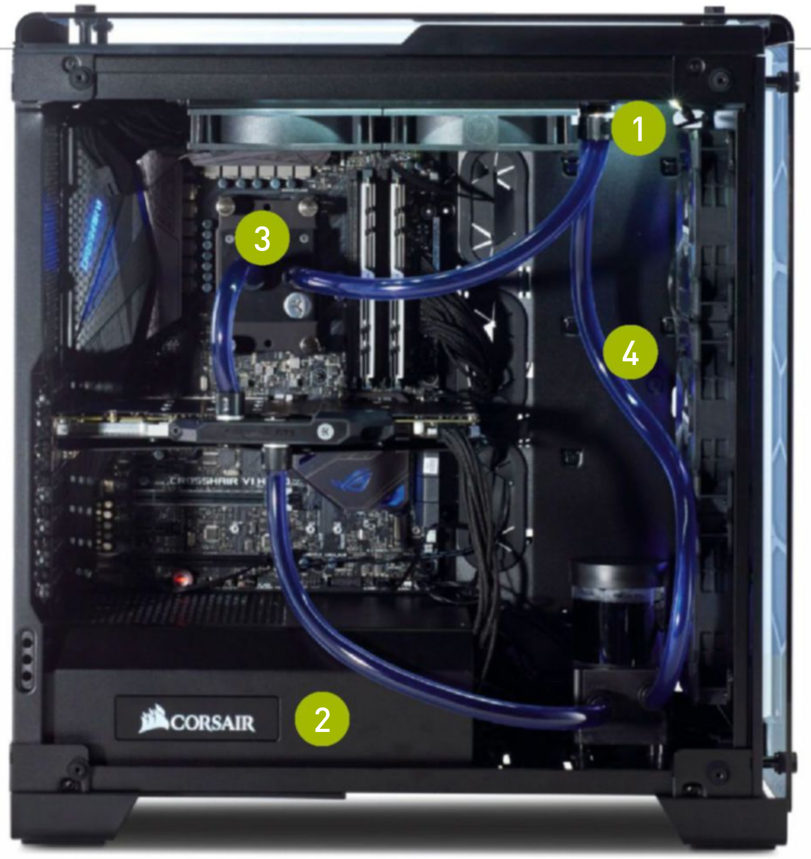
EK'S FLUID GAMING KITS may be a sweet deal, but the lack of angled fittings can make some of the tubing runs slightly difficult to set up. The problem is, if you run too short a length of tubing, you can get kinks in the tube, cutting off the flow entirely, which is something you absolutely want to avoid. Too long, on the other hand, and it can look unwieldy and messy, and again could develop a kink somewhere. Give yourself about an inch more tubing than you think you'll need, and slowly cut off segments until you're satisfied that there are no kinks in the run.

6

REAR I/O APLENTY

IT WOULDN'T be "Build It" without a shot of the rear I/O, right? Asus's Crosshair Hero VI is one of the best specced motherboards out there if you're a peripheral-happy power user, like us. Featuring a staggering 9x USB 3.1 Type A, 4x USB 2.0, and, of course, a USB 3.1 Type C, just for good measure, there's a port for everything, and even we can't fill them all up. It's not all USB ports, however—there's a BIOS reset switch, clear CMOS, integrated A/C Wi-Fi, 5.1 audio out, and Intel Gigabit Ethernet, too. What's not to love?





1 Here are those CableMod LED strips in action yet again. One single 30cm strip placed along the top of the chassis really helps make the hardware pop.

2 The PSU here is a something of an old office beastie. Running for over two years now, the BitFenix Alchemy 750W is still available today, and comes with black braided cables.

3 If you want to have some overclocking fun with liquid cooling, grab a Ryzen 7 1700 instead of the 1800X, drop the memory to 16GB, and you should see similar performance for a lot less cash.

4 By default, EK provides you with clear coolant in the A240G kit, so we picked up some purple dye from Mayhems for $9, and added a couple of drops to the reservoir loop after it was filled.

LUST FOR LIQUID

WE HAD A TON OF FUN constructing this build—and converting it over to liquid cooling was fairly painless. Plus, watching those GPU temps drop so dramatically was simply joyous. We're still not 100 percent happy with the whole shebang, but at just $260 for the loop, we can let EK off. Our tubing runs are a bit too long, and if EK had included a vertical bracket instead of a horizontal one, we'd have mounted the radiator in the front of the chassis, then attached the bracket and the res to it.

Cooling aside, the system runs a treat. That Ryzen 7 1800X certainly doesn't disappoint, smashing through Cinebench with a score of 1,597, and providing some solid single-core performance, too, at 159—comparable to a stock clocked Skylake Core i5, which is more than enough for us in any game.

It still has issues in certain older titles; frame stuttering is definitely there, but it's not the end of the world, and as drivers advance with Ryzen in mind for modern titles, it's hardly a big loss. The biggest problem is our sudden envy over eight-core systems. Watching the rendering times of videos fall, and those 16 little squares eat up Cinebench in seconds, made our Core i7-6700K systems seem a little lackluster. Sure, they're great in game, but the lack of computational throughput leaves a sour taste in our mouths.

One thing we haven't really covered is the lack of storage. We'll be honest, the deadlines were particularly tight for this one, and getting a system set up and ready to go for our cover shoot was a challenge. As always, it had to look good and function almost immediately, so we went with the easy option, and just threw a 275GB Crucial MX300 SSD at it, and that's about it. In the real world, that wouldn't be enough for a system of this caliber. Investing in a 1TB SSD, or even an SSHD, to mount in the back of the chassis, would more than make up for the lack of internal storage. And you could just as easily run a PCIe SSD on the motherboard, and swap out the SSD for something more budget and capacity oriented.

Memory performance intrigued us—latencies have fallen dramatically with Ryzen recently—once upward of 100ns, they've now fallen to 78ns and below. Whether that's down to better BIOS, or benchmarking software now registering Ryzen properly, is up for debate, but either way, it feels smoother.

So, was it worth it? If you've read our liquid cooling feature (pg. 36), the answer remains the same: yes. The cooling is staggering, especially on that GPU, and the performance is solid. Cryptocurrency mining is still butchering GPU prices for now—something that looks unlikely to abate any time soon—but this is still a fairly decent price point for the performance, and it looks killer to boot.

BENCHMARKS

	ZERO-POINT	
Cinebench R15 Multi-Thread	987	1,597 (62%)
Cinebench R15 Single-Thread	196	159 (-19%)
TechARP's X264 HD 5.0.1 (fps)	21.93	35.36 (61%)
CrystalDisk QD32 Sequential Read (MB/s)	1,895	532 (-72%)
CrystalDisk QD32 Sequential Write (MB/s)	949	495 (-48%)
Rise of the Tomb Raider (fps)	41	57 (39%)
Far Cry Primal (fps)	76	78 (3%)
The Division (fps)	78	82 (5%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our desktop zero-point uses a Core i7-6700K CPU @ 4.6GHz, an AMD R9 Fury X, and 32GB of RAM. All games are tested at 1080p on max settings, with HD texture packages installed.

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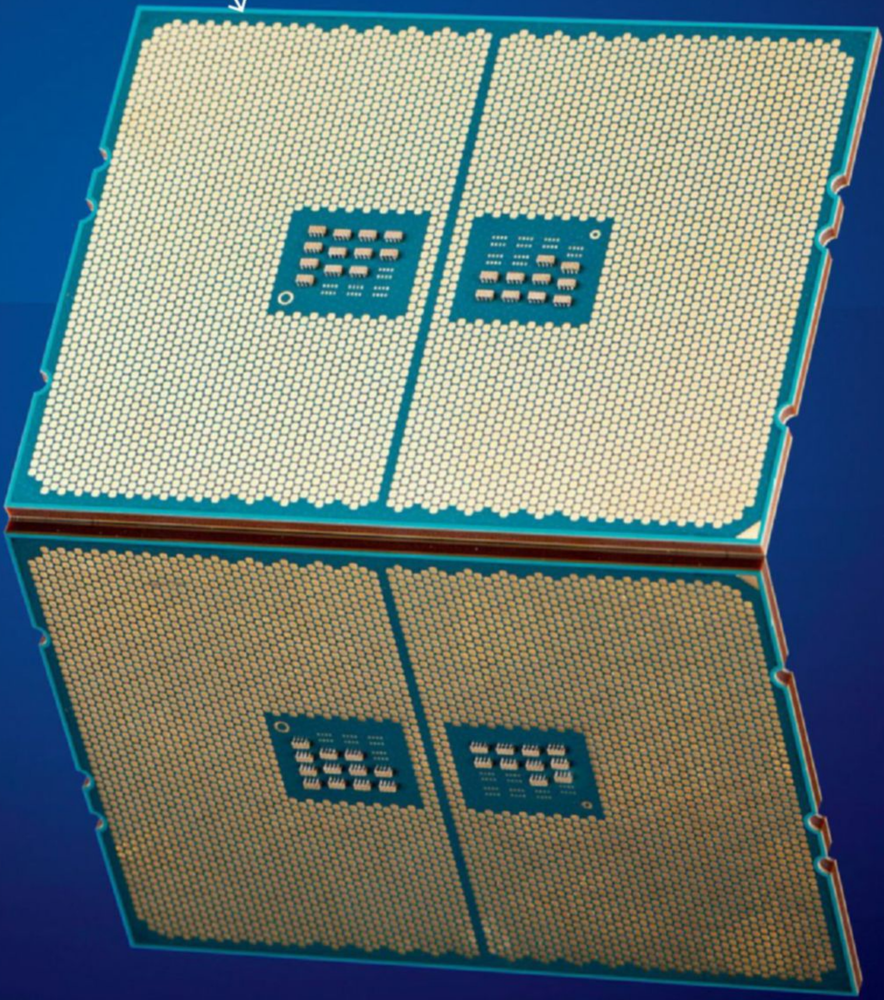

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There are simply no words—we're blown away.

Ryzen Threadripper 1950X

Amazingly, AMD ups the ante again

RIGHT NOW, Intel ought to be asking AMD what the hell it's making that glue out of, because this thing is amazing. A vast swathe of the tech community has long had a hunch that something bigger was creeping over the horizon from the plucky red underdog, and it hasn't been disappointed. Ryzen hit a very impressive mark with its launch, but lacked a lot of the high-end features that Intel's X99 platform brought to the table. Its lack of PCIe lanes, no quad-channel memory support, and a slightly underwhelming chipset made the platform more akin to mainstream, while the number of cores cemented the 7 series at the very top of our PC rendering wish list.

Fast-forward five months, and we've been graced with what can only described as a monster. Especially if you're in the market for a professional grade workstation setup. In short, Threadripper is incredible. The 16 cores harbored inside its CPU die are unlike anything we've ever seen. Think of this as two Ryzen 7 1800Xs, working in tandem inside a single CPU. AMD wasn't joking when it announced its infinity fabric, and the similarities between that top-end mainstream core and this mighty monster are more than just in name.

But before we delve into the heady heights of performance, let's talk about the socket installation process, because it's a doozy. This is the first consumer AMD processor we've seen that doesn't run off the pin grid array standard. Based on EPYC server chips, we're greeted with a sight we usually associate with Intel: pins, lots of them—4,094, in fact. Because it's so large, each chip needs to be held securely in place. To install your Threadripper, you unscrew three Torx screws, which release a spring-loaded retention bracket. Once past that, you lift up another bracket, with a protective socket cover inside. You slide that cover up and out of the internal bracket, and slip your shiny new Threadripper CPU (on its included orange tray) into the bracket, before gently lowering the internal bracket back down into position, and resecuring the top bracket.

Right, OK, performance. Let's get to the good stuff. So, by default, Threadripper runs at a max turbo of 3.7GHz across all 16 of its cores. What that equates to in the real world is stock scores of 3,000 points in Cinebench R15, with 167 in single-core mode. Fry Render wrapped up its ray-tracing in 84 seconds, and Tech Arp's X264 pulled in a staggering 63.44fps. Gaming was a mixed bag. By default, Threadripper, with AMD's Master Utility installed on desktop, has two modes: your standard creative mode, with all 16 cores active, and memory set in UMA (Uniform Memory Access) mode, or "gaming mode," with eight cores active (overclocked to 4.1GHz), and with the memory running in NUMA (non-UMA). In creative mode, all our tests performed as we expected. *Atilla* came in at 35fps, *Far Cry Primal* at 75fps, *Tomb Raider* actually bested all of our other processor tests at 44fps, and *Deus Ex*, well, that's still murderously slow at 13fps—same across both Intel and AMD.

What really blew us away, though, was how easy it was to overclock. We did some seriously vigorous testing using our usual methodology, and tried something a little more basic, too: Set the CPU Ratio to 40 in the BIOS, disabled "Spread Spectrum," tweaked the VRMs to operate at "Extreme," headed to desktop, ignored voltage, and boom! 4.0GHz across all 16 cores. We saw a Cinebench R15 score of 3,448 points, and X264 smashed in at 73.4fps—a 15 percent increase in performance. Stunning.

How can we sum up Threadripper? It's a tough one. It's incredible, no doubt, its pricing is phenomenal, and it can game just as well as any of the other Ryzen parts we've tested. Couple that with its astronomical computational performance, and stunning overclocking capabilities, and it's unlike any other. **–ZAK STOREY**

BENCHMARKS

	AMD Ryzen 7 1950X	Intel Core i9-7900X
X264 Benchmark (fps)	**63.44**	45.12
Cinebench R15 Single (Index)	167	**180**
Cinebench R15 Multi (Index)	**3,012**	2,218
Fry Render (Seconds)	**84**	94
AIDA64 Memory Latency (Nanoseconds)	87.6	**71.8**
Total War: Atilla (fps)	35	**41**
Far Cry Primal (fps)	75	**77**
3DMark: Fire Strike (Index)	**18,898**	18,302
Maximum OC (GHz)	4.0	**4.6**
Cinebench R15 Multi OC (Index)	**3,448**	2,466

Best scores in bold. Our test bed consists of an Asus X370 Crosshair VI Hero, an Asus Maximus IX Hero, 16GB (2x 8GB) of Corsair Dominator Platinum DDR4, an Nvidia GeForce GTX 1080, and a 500GB Samsung 850 Evo.

VERDICT
9
KICK ASS!

AMD Ryzen Threadripper 1950X

+ **MASTER CRAFTED** Phenomenal performance; exceptional price; 60 C OC thermals; secure mounting; solid gaming.

− **GLUED TOGETHER** A bit big?

$1,000, www.amd.com

SPECIFICATIONS

Base Clock	3.4GHz
Turbo Clock	4.0GHz
Cores	16
Threads	32
Lithography	14nm
Cache	L3 40MB
Memory Support	128GB DDR4
Memory Channels	4
Max PCIe Lanes	64
TDP	180W

The EON17-SLX's sleek look is a nice change of pace from aggressively styled gaming laptops.

Origin EON17-SLX

Desktop power, minus the desktop

WE'VE BEEN EVALUATING a lot of lower-powered laptops in the last few months. Well, in relative terms at least. You can get a lot of mileage out of a GTX 1060 or 1070-powered mid-tier laptop, especially if all you're interested in is gaming at 1080p. But for gaming at 4K, and benchmarks that match up to high-end desktops, you're going to need something more.

The EON17-SLX from Origin PC is just that—all the components and performance of a top-end desktop PC crammed into a portable machine. Sure, it's heavy and bulky for a laptop, weighing 12 pounds (not including the two 330W power bricks) and measuring just shy of two inches thick, but that's to be expected, considering the components inside.

Let's start with the CPU. The EON17-SLX we tested opts for a desktop-class Intel Core i7-7700K clocked at 4.2GHz. Combined with 32GB of DDR4-2400 RAM, the EON17 scored some of the highest benchmarks we've ever seen for a laptop. In Cinebench R15, the EON17 scored 893, which blows out our (admittedly out-of-date) laptop zero-point, and nearly matches the bar for desktops. TechARP's x264 told a similar story: 19.76 blows out the laptop competition, and nearly matches some of the best desktops we've tested.

Storage is also an area where the EON17-SLX excels, because its primary storage is handled by a super-fast 512GB Samsung 960 Pro NVMe SSD—more than enough for the OS and several large triple-A games. If that's not enough, the 960 Pro is backed up by a 2TB Seagate FireCuda flash-accelerated HDD. That's a ton of snappy storage space that makes the EON17 an excellent mobile workstation.

TWO FOR THE ROAD

Now let's talk games. For pixel-pushing, the EON17-SLX packs two Nvidia GeForce GTX 1080s—the kind of hardware that makes gaming at 1080p seem rather pointless. Nonetheless, we conduct our gaming benchmarks at 1080p, so bear with us as we go through some numbers we would classify as "overkill."

Far Cry Primal was the EON17's weakest showing, with a frames-per-second score of only 91 in the game's built-in benchmark. That's still a good 20–30fps higher than most laptops we've tested, but not especially impressive compared to desktop hardware. *The Division* was a different story, with the EON17's 137fps nearly doubling the desktop zero-point. We saw the same thing in *Rise of the Tomb Raider,* where the EON17 scored an average of 115fps across the game's three-part benchmark (163fps in the Mountain Pass, 101fps in Syria, and 80fps in the Geothermal Valley)—much higher than both our laptop and desktop zero-points. 3DMark Fire Strike returned a score of 24,498—similarly impressive, even by desktop standards.

Like we said, it's overkill for 1080p. But what about 4K? Origin's EON17-SLX is available in 1080p, 1440p with 120Hz refresh rate, or 4K at 60Hz refresh variants, all with G-Sync. The unit we tested was the 4K variant, which seems the most apt for a GTX 1080 SLI loadout—especially considering that SLI doesn't always play nice at 1080p.

The pair of cards performed handily at 2160p, maintaining average frame rates above 60fps in every gaming benchmark we performed. *Rise of the Tomb Raider* returned scores of 94fps in the Mountain Pass, 71fps in Syria, and 70fps in the Geothermal Valley, for an average of 79fps. Similarly impressive, *Far Cry Primal* and *The Division* scored 75fps and 64fps, respectively. Of course, laptop or not, most top-end gaming rigs that offer that sort of performance come with a price tag to match. The EON17-SLX is no different, coming in at a few hundred dollars shy of five grand for the unit we tested. That's a big pile of cash—but, hey, you can't take it with you. The EON17, you can. **–BO MOORE**

VERDICT
9
KICK ASS!

Origin EON17-SLX

+ KING OF THE ROAD Portable 4K performance; snappy storage sleek design.

− OUT OF GAS Thick and heavy; just as expensive; requires two large power bricks.

$4,787, www.originpc.com

SPECIFICATIONS

Processor	Intel Core i7-7700K @ 4.2GHz
Graphics	2x Nvidia GeForce GTX 1080 8GB SLI
RAM	32GB DDR4-2400
Screen	17-inch 4K IPS G-Sync
Primary Storage	512GB Samsung 960 Pro PCIe NVMe M.2 SSD
Secondary Storage	2TB Seagate 2.5-inch FireCuda flash-accelerated HDD
Keyboard	Backlit multi-color keyboard
Battery	89Wh
PSU	2x 330W PSU
Weight	12lb

BENCHMARKS

	ZERO-POINT	
Cinebench R15	682	893 (31%)
TechARP's x264 (fps)	15.17	19.76 (30%)
CrystalDiskMark 4K Read	44	55 (25%)
CrystalDiskMark 4K Write	162	186 (15%)
Far Cry Primal (fps)	37	91 (146%)
The Division (fps)	33	137 (315%)
Rise of the Tomb Raider (fps)	42	115 (174%)
3DMark Fire Strike	6,583	24,493 (272%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our gaming laptop zero-point is the Asus G752VT-DH72, with an Intel Core i7-6700HQ, a 3GB GTX 970M, and 16GB of DDR4-2133.

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AMD Ryzen 3 1300X

Another month, another Ryzen to screw with Intel

RYZEN 3 IS THE LATEST, and most affordable, subset of AMD's Ryzen family. Coming in two different guises, the Ryzen 3 1300X is the faster offering, packing support for XFR and a slightly faster clock speed over the Ryzen 3 1200, and it's completely unlocked. It is also $20 more expensive than the 1200, although rolling in at $129, it's still very much a budget offering.

The big news, when compared to Ryzen 5 and 7, is that Ryzen 3 doesn't offer SMT support. Which means you get four cores to play with, but that's it. No extra cleverness to make the chip handle eight threads at once. Much like an Intel Core i5, then, albeit one that is closer in pricing to a Core i3. For this reason, we've compared it to the Core i5-7600K in our benchmarks, although such a chip will set you back $220.

So what does that $130 net you? A quad-core chip with a base clock of 3.5GHz, turboing up to 3.7GHz. AMD's XFR (eXtend Frequency Range) will see this boost up to 3.9GHz, provided there is sufficient cooling. The Ryzen 3 1300X has a TDP of 65W, and ships with AMD's Wraith cooler, which keeps the chip in check quite comfortably and quietly. For our main testing, we swapped to the NZXT X62 Kraken, which we use for all of our CPU benchmarks.

There are no real surprises with the rest of the specifications, with the same 384KB of L1 cache and 2MB of L2 cache that you'll find on the other chips in the Ryzen family. Where it does deviate is in the amount of L3 cache—matching the 8MB of the Ryzen 5 1400, as opposed to the 16MB you'll find in the other chips. Again, this may lead you to think that the core configuration is a single Ryzen core complex, but as with the 1400, this isn't the case; it's a similar 2+2 configuration that we're used to, just with some of the cache turned off, and SMT disabled.

As for performance, there's a lot to like from such an affordable little package, especially when you consider that you'll be able to slot this into a bargainous B350 motherboard and have a decent base for around $200. We'll admit that it's odd seeing only four little boxes complete the Cinebench test, especially as we've quickly got used to seeing eight, 16, or even 32 of them, but the score is still solid enough. Single-threaded performance is still off the pace of Intel's, but compared to a Core i3, this is a strong win for AMD.

Games continue to favor Intel's chips, although the difference isn't as profound as it was when Ryzen first hit our test benches. Intel's slightly higher base clock helps here as well. Even so, there are only a few frames per second in it, with *Total War: Attila* managing 36fps to the Core i5's 40fps, and *Far Cry Primal* recording 73fps to Intel's 77fps.

Overall, it's hard to argue against the Ryzen 3 1300X. It's a decent performer at a competitive price. Not a halo chip, like Threadripper, but it should still find its way into plenty of systems, and rightly so. If you're in the market for a budget machine, this is a strong starting point. The only thing it doesn't offer the budget buyer is integrated graphics, so until AMD releases its Ryzen APUs, there's life in Intel's Core i3s and i5s yet. –**ALAN DEXTER**

BENCHMARKS

	AMD Ryzen 3 1300X	AMD Ryzen 5 1400	Intel Core i5-7600K
X265 Benchmark (fps)	12.64	13.61	**15.86**
Cinebench R15 Single (Index)	139	131	**179**
Cinebench R15 Multi (Index)	550	**693**	663
Fry Render (Seconds)	462	380	**346**
AIDA64 Memory Latency (Nanoseconds)	78	80	**58**
Power Draw Idle (Watts)	56	55	**44**
Power Draw Load (Watts)	95	**93**	103
Total War: Atilla (fps)	36.1	33	**40**
Far Cry Primal (fps)	73	71	**77**
3DMark: Fire Strike (Index)	14,152	14,528	**15,762**
Maximum OC (GHz)	3.9	4	**5.2**

Best scores are in bold. Our test bed consists of an Asus X370 Crosshair VI Hero, an Asus Maximus IX Hero, 16GB (2x 8GB) of Corsair Dominator Platinum DDR4, an Nvidia GeForce GTX 1080, and a 500GB Samsung 850 Evo.

VERDICT 9

AMD Ryzen 3 1300X

+ **PRUDENT** Great value for money; decent cooler; four real cores; unlocked.

− **RECKLESS** No SMT; still lags behind Intel for gaming.

$130, www.amd.com

SPECIFICATIONS

Base/Turbo Clock	3.5GHz/3.7GHz
Cores/Threads	4/4
Lithography	14nm
Cache	8MB L3
Memory Support	DDR4
Memory Channels	2
Max PCIe Lanes	20
TDP	65W

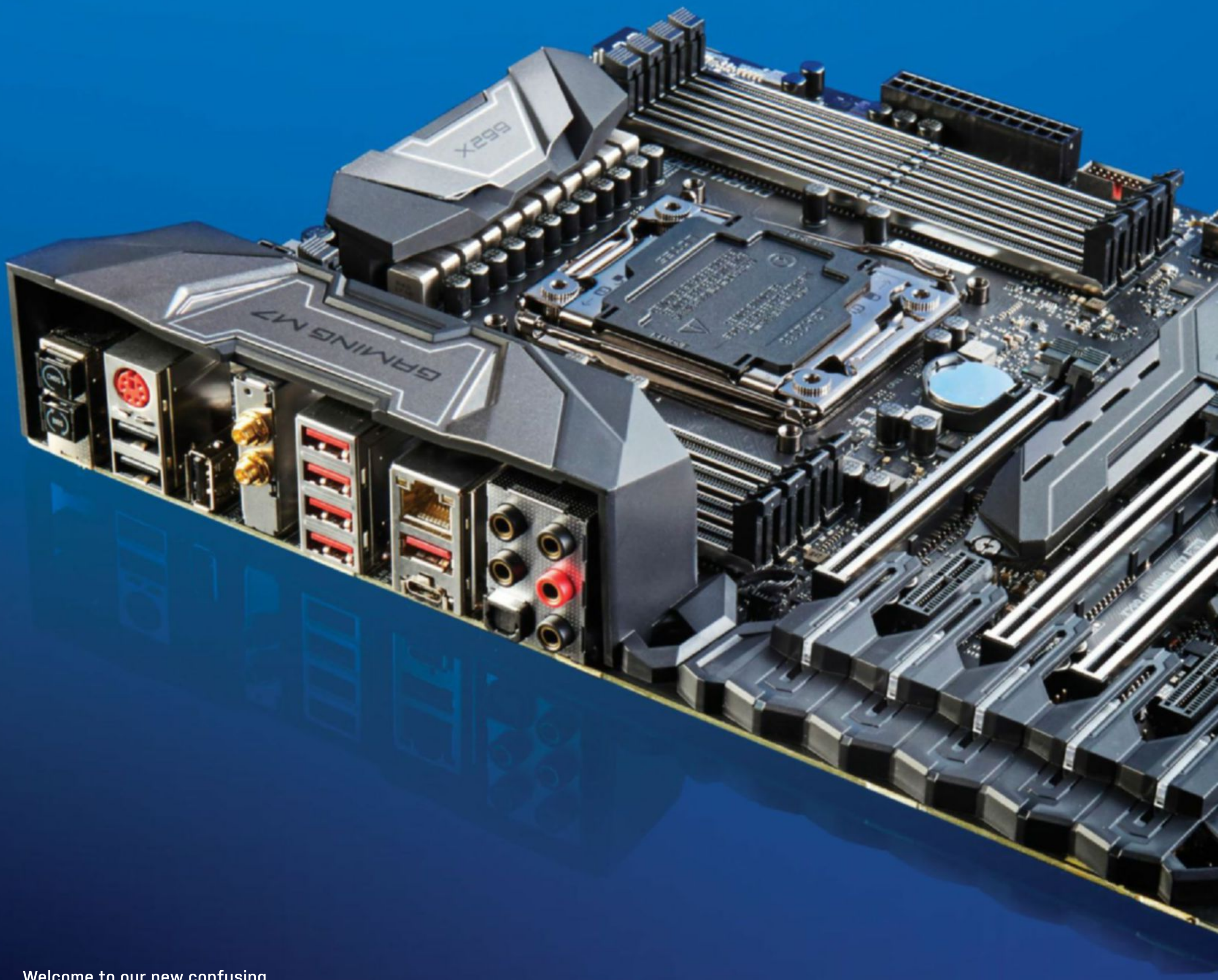
MSI X299 Gaming M7 ACK

Mobo LEDs done right?

INTEL, WHAT ARE YOU DOING? The X299 platform is so confusing. This is the first time we've had the opportunity to look at two X299 boards side by side, to identify whether one is better than the other. To do that, we had to choose a selection of parts. For X99 and Z270, the choices were obvious. Here, though, we have processors ranging from $250 to $1,800—and higher—so what do we use? Is this a high-end platform or a mid-range one? Ultimately, we had two choices: either the high-clocked 4.3GHz Core i7-7740X, or the 10-core Core i9-7900X. We went with the middle ground, at least until Intel starts shipping six and eight-core samples out to us reviewers.

So, then, on to the board in question. And, boy, is it a stunner! MSI really has hit the ball out of the park with this one. The M7 ACK is a brand new refinement of MSI's gaming line. The odd-looking tribal dragon still shows its face on the chipset, but the RGB LEDs are subtly baked into the rear I/O cover, PCIe slots, and the VRMs just north of the processor. The subtle flecks of silver dotted across the chipset scream premium, and unscrewing the chipset cover reveals a hinge, enabling you to lift up the heatsink, to allow for installation of up to two M.2 PCIe SSDs, complete with (hopefully improved) thermal pads for each drive.

On top of that, the board supports up to four-way SLI, if you have the correct processor, up to 128GB of DDR4 at 4,133MT/s, eight SATA 6Gb/s ports, one of



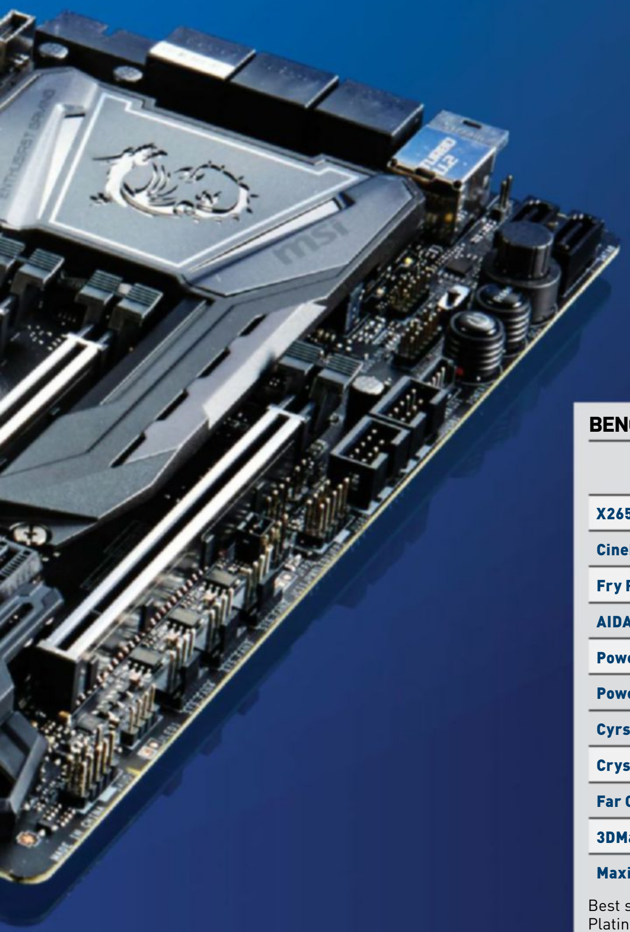
Welcome to our new confusing test bench standard.

Intel's swanky U.2 ports, and a whole horde of USB 3.0 and 2.0 ports. It's the rear I/O that really shines on the M7 ACK, however, with CMOS and BIOS reset switches (with two onboard BIOS by default), four USB 3.0 ports, three USB 2.0 ports, Killer Gigabit Ethernet, USB 3.1 Type C and Type A, wireless AC, and an incredibly well-equipped 5.1 audio solution, with optical-out as well.

As always, the performance differences between motherboards were slim. Overall, we haven't seen anything particularly spectacular from any of the boards we've reviewed since before P67 and Sandy Bridge launched all those years ago. That said, the areas that did stand out include memory latency, coming in at an impressive 64.8ns (5ns faster than Dream Machine 2017). Also interesting were the results of our power draw test—in particular, how it compared to the Z270 boards that Kaby Lake launched with last year, because it was near identical. Even given the higher TDP on the chip itself, during our five-minute run, the board didn't pull more than 142W from the wall—identical to the Asus Maximus IX Hero, and only 11W more than MSI's own XPower Gaming Titanium.

And if overclocking is your thing, the ACK has you covered. Those VRMs along the top are no slouches, and with our Core i7-7740X, we comfortably managed to achieve 5.0GHz at 1.24V on the V Core. Although not as in-depth as its competitors, MSI's BIOS is incredibly intuitive and easy to use—plenty for the casual overclocker looking to get a little extra kick out of their chips.

The M7 ACK is a solid all-around motherboard. It performs well in almost all of our benchmarks, and overclocks like a trouper. Couple that with its slick aesthetic and commendable expandability, and it's well worth investing in if you're looking to jump on to Intel's new platform. We definitely recommend going for an Intel Core i7-7800X minimum with this setup, to gain access to those PCIe lanes and avoid memory confusion, but if you've got the cash, it's a damn fine mobo. **–ZAK STOREY**



SPECIFICATIONS

Chipset/Socket	X299/LGA 2066
Form Factor	ATX
Memory Support	128GB DDR4 @ 4,133MT/s
M.2/U.2 Support	2x M.2 PCIe x4, 1x U.2
SATA Support	8x SATA 6Gb/s
Max PCIe Support	4x PCIe 3.0 x16 (x16x4x16x8)
Rear I/O	Wireless AC, BIOS reset, CMOS reset, combi port, 3x USB 2.0, 4x USB 3.0, 1x USB 3.1 Type A, 1x USB 3.1 Type C, Killer Gigabit Ethernet, 5.1 audio, optical out

VERDICT
9
KICK ASS!

MSI X299 Gaming M7 ACK

+ **ACK ACK ACK** Solid performance; fantastic aesthetic; good power draw on Kaby; overclocking pedigree.

− **PEW PEW** A touch pricey; M.2 compatibility needs improving.

$400, www.msi.com

BENCHMARKS

	MSI X299 Gaming M7 Ack	Asus Prime X299 Deluxe
X265 (fps)	20.87	**21.06**
Cinebench R15 Multi (Index)	**984**	970
Fry Render (Seconds)	221	**213**
AIDA64 Memory Latency (ns)	64.8	**56.2**
Power Draw Idle (W)	**46**	47
Power Draw Load (W)	142	**131**
Cyrstal Disk Sequential Read (MB/s)	**551**	**551**
Crystal Disk Sequential Write (MB/s)	**534**	526
Far Cry Primal (Avg fps)	**42**	**42**
3DMark: Fire Strike Extreme (Index)	**9,524**	9,474
Maximum OC Achieved (GHz)	**5.0**	**5.0**

Best scores are in bold. Our test bed consists of an Intel Core i7-7740X, 32GB (4x 8GB) of Corsair Dominator Platinum DDR4 2400, an Nvidia GeForce GTX 1080, and a 500GB Samsung 850 Evo SSD. *Far Cry Primal* tested at Ultra at 4K.

ViewSonic XG2530

If you have the need, this ViewSonic has the speed

IN THE BAD OLD DAYS of the 2000s' CPU wars, megahertz became megahurts as the pursuit of clock speed for the sake of clock speed pushed Intel's engineers down an architectural dead end. Is something similar happening now with PC monitors and the quest for ever higher refresh rates?

Enter the ViewSonic XG2530. It blows straight through the likes of 120Hz and 144Hz, and motors right on up to 240Hz. That is one hell of a refresh rate. OK, it's not the first monitor we've seen with such a capability, but it remains a startlingly high refresh rate. Moreover, it's hard to put a finger on exactly where to draw the line with this particular technology, to grasp what the human eye can even perceive.

For instance, it's worth remembering that when it comes to movies, 24fps is standard, and 48 qualifies as a special HFR or "high frame rate." OK, movies and PC monitors are not directly comparable, but that does put 240Hz into some kind of context. First, though, let's consider the XG2530 as a monitor in a general sense.

It's a 25-inch model, with a modest 1920x1080 or 1080p resolution, though given the refresh rate, and the bandwidth and pixel-processing implications of the 240Hz refresh, that's to be expected. Beyond that, it's not hugely remarkable on paper. The chassis and stand are quite high quality, with a full range of adjustability. There's support for AMD's FreeSync tech. Oh, and TN panel technology.

Again, that's not a huge surprise, given the 240Hz refresh. TN is the quickest panel type. What is a pleasant surprise is the quality of this particular TNer. We've seen nice TN monitors before, but until now, they've all been 4K models. To be clear, we're not talking here about resolution and sharpness. It's colors and contrast where the XG2530, like those 4K TNers, shines.

By those metrics, this TN panel has closed much of the gap with a middling IPS panel, and surpassed a cheap 6-bit IPS screen fairly comfortably. Saturation levels are very high, and static contrast is strong, combining to deliver a very pleasant, punchy overall appearance. If you really want to be critical, there are faults. Most notably, the viewing angles are pretty much garbage—but, then, that's TN for you.

Beyond that, we're talking details, including some obvious banding in standard gradient images. More problematic is the panel's overall accuracy. There is some compression in darker tones that can lead to a loss of detail in games and movies—not catastrophic, but something you don't have to put up with when using a good IPS panel.

That 1920x1080 resolution makes for limited desktop space, of course, and paired with a reasonably expansive 25-inch diagonal, results in a fairly coarse pixel pitch. In this age of crazy-high DPI phones and tablets, a low-resolution monitor like this seems seriously ugly in comparison.

But then there's the 240Hz shizzle. We admit that some may not sense the subjective benefit versus what you might call a regular 120Hz panel. But we can feel the difference, even if it's not as significant as going from, say, 60Hz to 120Hz. A 240Hz screen makes for incredibly responsive gaming. Up to this point, at least, it's not just about putting bigger numbers on the spec sheet. Combined with zappy pixel response and the punchy panel quality, it's a very compelling gaming proposition. A different proposition compared to, say, a 4K 60Hz panel and the detail that can offer, but compelling all the same. **–JEREMY LAIRD**

VERDICT

8

ViewSonic XG2530

+ **KEANU REEVES** Super-quick response; surprisingly good TN panel quality.

− **JASON PATRIC** Modest native resolution; pricey for a 25-inch TN panel.

$493, www.viewsonic.com

SPECIFICATIONS

Panel Size	25-inch
Native Resolution	1920x1080
Pixel Density	88 ppi
Panel Type	TN
Maximum Refresh	240Hz
Response	1ms
Contrast	1,000:1
Display Inputs	DisplayPort, 2x HDMI
Connectivity	USB 3.0
VESA Mount	100 x 100mm
Warranty	Three years

ViewSonic's latest gaming panel socks a 240Hz punch.

Asus ROG Strix Magnus

Novel deodorant stick or desktop mic? You decide

SO, IT'S COME TO THIS: Asus is trying to sell you Optimus Prime's beard trimmer. Like streamers didn't already have enough to answer for, the ROG Strix Magnus is the latest manifestation of their influence, a USB-powered, desktop mic, designed for in-game chat and broadcasting. As such, it comes with all the features you'd expect from a product that carries the word "gaming," but doesn't strictly have much to do with gaming: customizable RGB lighting, accompanying software, and a braided cable.

But let's give the Magnus a fair chance—there's a definite gap in the market for a product like this. Streamers have migrated away from the scratchy world of headset microphones in favor of quasi-studio mics, such as Rode's NT-USB and Audio-Technica's AT2020USB+, both priced slightly below this model. The benefits are obvious: vastly improved sound, and more control over it, too. Do you need one? Probably not, but people don't strictly need fidget spinners either, yet here we are. Perhaps the more pertinent question is whether Asus's bespoke gaming effort can offer something meaningful over the aforementioned current favorites, both of which are produced by companies with significant heft in the pro audio space.

SEE THE LIGHT

That's a hard question to answer. Really, it depends on how much value you place on RGB lighting, because elsewhere there's not much to indicate that the Magnus is a no-brainer for gaming and streaming usage. Admittedly, it's an easy setup job: Pull the mic out of its carry-case (a welcome inclusion), attach the meaty braided USB cable to the mic input and an available USB 3.0 port, and you're done. Seriously—that's it. You can use a USB 2.0 port in a pinch, with limited functionality and—gasp—no RGB lighting, but it's preferable to just give it the juice it needs. You can use Asus's own Aura software to further customize the lighting, but surprisingly, there are no further options for the audio itself. That absence is keenly felt when it comes to the "ENC" noise cancelation mode—in our testing, we found it too aggressive, clipping consonant sounds and producing a really low overall sound quality. The ability to adjust the noise gate manually would go some way toward alleviating that, but that's not possible unless you start running VSTs and plugins in front of it when recording with your DAW of choice.

ENC is one of three mic pattern modes available here, along with a cardioid (unidirectional) and stereo (bidirectional) pattern. Cardioid is the most useful for broadcasting, because it's the pattern with the least background noise pickup, and gives your voice the most clarity. If you did want to get all the ambient noise from your recording environment, too, stereo mode is there, but we're not sure how useful you'd find it. Even when recording two people next to each other, the cardioid pattern produces the best results. As for the quality of your cardioid recordings and streams, it's definitely fit for purpose. The lower end frequencies are conveyed infinitely better than a headset mic could manage, and the signal is much cleaner, too.

There is a problem, though, and it comes with the price point. The Magnus certainly isn't at the level of studio mics, such as Audio-Technica's AT4050, and that's reflected in the fact that it's almost half the price. The latter would require more hardware between itself and your PC, too. But it also isn't at the level of the aforementioned AT2020USB or NT-USB, the latter of which also comes with a pop shield and tripod stand, which this package is without. The difference is in the clarity and low end of the recorded sound—sadly, the Magnus seems flimsy by comparison. On those grounds, it's hard to recommend this one—unless you're a Transformer with a bit of unwanted stubble around the jawline, that is. –PHIL IWANIUK

VERDICT **7**

Asus ROG Strix Magnus

⊞ **LOUD AND PROUD** Easy setup; three patterns.

⊟ **RIVER STRIX** Thin sound; lacking software support.

$180, www.asus.com

SPECIFICATIONS

Recording Patterns	Unidirectional, bidirectional, omnidirectional
Sample Rate	48KHz
Bit Rate	24-bit
Frequency Response	20Hz–20KHz
Capsules	3x 14mm condenser
Connectivity	USB 3.0

Cherry B.Unlimited 3.0

When gaming just isn't your thing

HALLELUJAH! It's not a gaming keyboard, for once. Yep, this time around we've left the mechanical clackers behind in favor of something a little more sophisticated. Cherry got in touch with us recently, curious as to whether we'd be keen to test out its latest iteration of the Cherry B.Unlimited 3.0 wireless keyboards. We're big fans of the key-crafting company, so naturally we stepped out of our comfort zone and said "Yes!"

Gaming keyboards are great, with mechanical switches usually littering those panels of aluminum, but in reality, there's almost always one major problem: the cable. No matter what you do, if a clean and tidy working aesthetic is your jam, the likelihood is that you're just not going to achieve it with a gaming keyboard. They look pretty, they feel great, but the clutter the cable adds is unavoidable, without drilling holes in your desk.

This is where Cherry comes in. Although it's not the first, the B.Unlimited 3.0 is a fantastic wireless keyboard and mouse combo, designed to work anywhere. It's quiet, clean-looking, and compact. Although it's not the cornucopia of "aerograde" aluminum, RGB lighting, and deep laser-etched key fonts we're used to, the plastic soft touch feels right at home, and its straightforward, clean, black key caps, with white etching, are simply clean and precise.

At first glance, you'd be forgiven for thinking this is just your standard membrane affair, but Cherry has incorporated a scissor switch into the board, capable of actuating 20 million times before failure. That's far cry from the 50 million rated hits Cherry's mechanical switches can take, but still plenty for anyone using it in the office. Other than that, there are calculator, email, home, and lock quick-keys located on the top-right. There's also a nice little battery LED indicator to let you know if you're running out of juice, and that's about it.

Speaking of juice, charging is managed by a single USB power adapter, not too dissimilar from those on laptops, although obviously far less juice is supplied.

ENCRYPTED EXPERIENCE

The big seller, however, is the 128-bit AES encryption included with the keyboard. By default, the B.Unlimited utilizes a tiny wireless USB dongle to connect both the keyboard and the included mouse, which operates on the 2.4GHz wireless spectrum, so it would be fair to be concerned about the safety of any confidential information. And if it weren't for that encryption, we'd be inclined to agree with you. Luckily, it doesn't cause any delay or lag when typing—it's an interesting concept, and using the keyboard is generally just a pleasant experience.

However, we feel as though Cherry could take the wireless experience further than it has done here. Mechanical switches, by default, don't require power to operate, merely to register the actuation of the switch. A wireless mechanical keyboard would be a godsend for anyone looking to build a clean desktop environment. Combine that with Cherry's legendary switches and good build quality, as found on its MX 6.0 keyboard, and the plucky company would be laughing all the way to the bank. You could even throw a pass-through on here for good measure, given the nature of the 2.4GHz wireless connection being used to power the devices.

Posturing aside, the Cherry B.Unlimited 3.0 is a simple yet elegant keyboard. For those who are fond of mechanical switches, using scissor switches does take some time to get used to, but they're still far more satisfying than the membrane alternative. If you've got $75 to spare, and desperately need a dependable, quiet keyboard and mouse you can plug and play anywhere, this is the one. **–ZAK STOREY**

VERDICT 9

Cherry B.Unlimited 3.0

+ CLICKETY AES 128-bit encryption; svelte design; plug and play; nice switch; fair price.

– CLACKETY Missed opportunity.

$75, www.cherryamericas.com

SPECIFICATIONS

Switch Type	SX (scissor)
Form Factor	Standard
Media Keys	None
Macro Keys	None
LEDs	None
N-Key Rollover	10 keys
Pass-Through	None
Dimensions	18.11 x 6.50 x 0.6 inches
Warranty	Two years

Logitech G PowerPlay

When you have a mouse to charge at large

GENIUS COMES IN MANY FORMS, some more flawed than others. See, for example, the Boy Scout who built a nuclear reactor in his parents' basement, then later got cornered by the cops, covered in radiation sores, for stealing Americium-laced smoke detectors to support his peculiar habit. Logitech is a company, like that oddly glowing youth, with a passion for progress, and the drive to make it happen. While its experimentation with PC peripherals is unlikely to send the five o to its door, we can't help but feel that Logitech's passion is, in a way, just a little dangerous: It's going to inspire future tinkerers to do awful things, particularly as this specific innovation is priced in such an insane manner that many interested users will avoid it like our scab-faced dabbler avoided lead-lined aprons.

So, what we have here is Logitech's G PowerPlay mouse mat. It's a big-enough pad, with a chunky and eminently clonkable USB-plugged module on its top edge, which lights up all nice when you plug it in. The box comes with two surfaces to choose from: a pleasing tight cloth and a stiff, thick, textured plastic. Oh, and there's a massive proprietary induction loop hidden beneath the mat, which beams power into whichever wireless-charging compatible mouse you happen to be using. Logitech has introduced two new mice to go with it, and sent both to us to test: the G703 ($99), a fairly standard four-buttons-and-a-wheel affair, and the delectable ambidextrous G903 ($149), with replaceable side buttons and a switchable ratchet/spin wheel. The latter is probably the best mouse we've had in our hands this year, despite its overly zealous price.

The key role of the PowerPlay pad is to act as an all-in-one mousing hub. Plug it in via USB, and it both acts as a wireless receiver and charges anything with the included PowerCore module installed (a magnetically mounted disc, which attaches to the bottom of the mouse), and it means your pad will retain compatibility with future mice in the range. The coil's design has been formulated to cover as large an area as possible, meaning that, at least as long as you don't intend to use the surface to charge anything other than a mouse, it blows Corsair's Qi-equipped Project Zeus concept out of the water before it's even had a chance to come up for air. Juice up your mouse by leaving it on a tiny pre-defined corner of the surface when it's not in use? Pah! This fires out its charging beam at all times, over a very wide area. While you have your hand over it. We don't know if this is a health risk—we're leaning toward no, but your opinion will probably depend on how well folded your tin foil hat happens to be. It could well be a battery risk, though Logitech's excellent Gaming Software restricts charging to 85-95 percent of mouse battery capacity in order to prolong the life of those non-replaceable cells.

UNNECESSARY EXPENSE

This is, really, some excellent hardware. It's a great concept, and it's been paired with a couple of great mice. A wireless receiver that close to the mouse means you'll almost never drop a single femtosecond of communication. But this thing is a hundred bucks. Add a mouse on top, and you're looking at a $200–$250 outlay, which is far too much. And you absolutely don't need the PowerPlay to make it work; both mice happily communicate with a tiny USB receiver, and charge periodically via USB. You might even find yourself using the mice via USB alone, just for that extra assurance in an online firefight. The PowerPlay has that nuclear allure, in that a wide-eyed competitor will one day skirt whatever patents Logitech has secured and ape this tech in much less elegant ways. We can't recommend getting in on the ground floor, but let's hope a more affordable version leaves Logitech's own labs sooner rather than later. **–ALEX COX**

VERDICT 7

Logitech G PowerPlay

+ CHARGED Great design; quality mousing surfaces; future-friendly.

− DISCHARGED Too expensive; completely optional device.

$100, www.logitech.com

SPECIFICATIONS

Dimensions	12.6 x 13.5 x 0.16 inches (mat), 1.7 x 5.3 x 0.4 inches (module)
Colors	Black, RGB lighting (logo)
Style/Material	Cloth, plastic
Warranty	Two years

Roccat Khan Pro

The world's first hi-res audio gaming headset

IN LATE 2014, the Japan Audio Society (JAS) and the Consumer Technology Association (CTA) agreed on a specification that products would have to meet in order to be allowed to wear the hi-res audio certification badge. Defining hi-resolution audio as "lossless audio that is capable of reproducing the full range of sound from recordings that have been mastered from better than CD quality music sources," the JAS and CTA require hardware to have a 20 Hz–40 kHz frequency response range in order to accurately reproduce that lossless sound. Although even the sharpest human ears can't hear anything above 20 kHz, all that extra headroom above it in the hi-res audio tech standard allows the full harmonic range of each sound to be voiced, which means a fuller sound in your ears, even if you can't perceive the individual frequencies.

Enter Roccat's Khan Pro headset. It's the first ever gaming headset to come with certified hi-res audio status, bringing that requisite 20Hz–40KHz response range in tow. Its marketing materials make all kinds of promises about transformative sound quality, and getting the edge on your competition—that sort of thing. But when you get right down to it, what does hi-resolution audio really do for a gaming headset?

We're pleased to report that the answer is: a great deal. We weren't immediately convinced by the Khan Pro upon taking it out of the box, because like other Roccat headsets we've tested, the construction materials and visual design here don't scream "premium." A largely plastic body and slightly creaky earcups prove to be only minor marks against the Khan Pro, though—elsewhere, it's a deceptively brilliant headset. Controls are kept to a minimum, with a simple volume scroll wheel at the back of the left earcup, and a mic mute function tied to the swingarm itself. We would ideally have liked a chat/game mix scroll, too, at this price point, but looking at the big picture of what these cans offer, we can let that one go. The braided cable connects via two 3.5mm audio jacks for mic and audio, rather than USB, and there's a single-input adapter for mobile devices included in the box. So far, so no-frills.

SPECIFICATIONS

Driver Type	50mm
Impedance	25 Ohms
Frequency Response	20Hz–40KHz
Design Style	Closed-back circumaural
Microphone Type	Electret condenser
Connectivity	3.5mm jack
Weight	8.11oz
Cord Length	8 feet

RESPONSE TIME

When you start pushing sounds through the Khan Pro headset, though, it's extremely difficult not to be impressed. Starting with a highly compressed YouTube video, it managed to find more clarity, bass response, and articulate mids, far better than most other headsets we've tested. Moving up into higher quality compressed audio, courtesy of Spotify's 320kb/s streaming, and older games with compressed audio files, the Khan Pro finds great sound there, too. Its response sounds similar to our ears to the venerable HyperX Cloud and Cloud II from Kingston, albeit with a slightly less emphasized low-end response. In other words, it's very good indeed.

It shouldn't be a surprise, then, that Roccat's hi-res audio certified cans sound dreamy when listening to lossless audio and games with uncompressed sound files, such as *Wolfenstein: The New Order* and *Titanfall 2*. The real question is: How often do you personally listen to hi-resolution audio? Because, while it's certainly growing in popularity in PC games, it's by no means the standard. (Pro tip: If the Steam install is less than 20GB, it's almost certainly not using uncompressed audio.)

So, is it true that Roccat's Khan Pro headset can give you the edge when playing multiplayer? To be honest, it's pretty unlikely. Most multiplayer games simply don't hit those fidelity levels, and you'd have to be playing at the very upper echelons of esports for something as incidental as the precision of footstep proximity to have a meaningful impact on your performance.

That isn't to say Roccat hasn't produced a really impressive headset—it has. In the process of hitting a technical standard that, let's face it, works primarily as a marketing tool, the Khan Pro can articulate great sounds from audio of all quality levels, with a fantastic stereo spread, and a reasonably flat response. If that exemplary sound quality came in a more luxurious overall package, this would be a genuine best-in-class contender. –PHIL IWANIUK

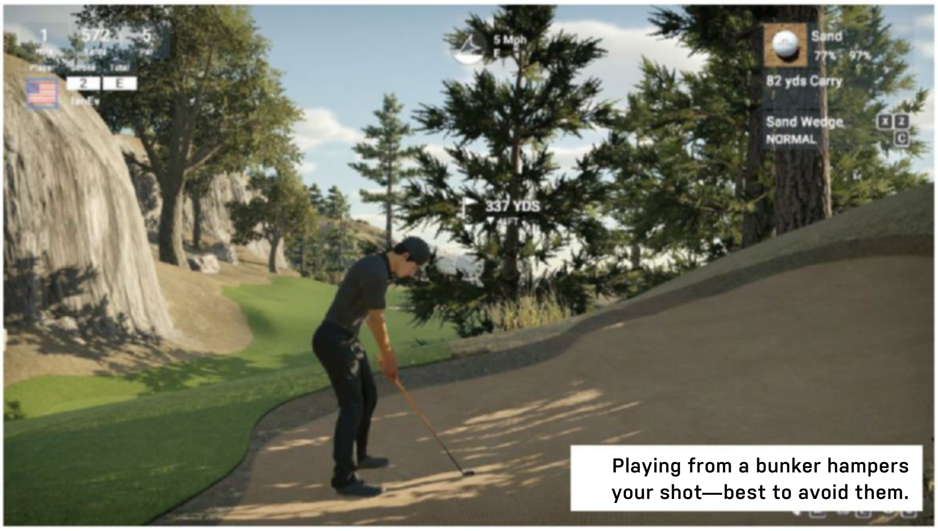
VERDICT
9
KICK ASS!

Roccat Khan Pro

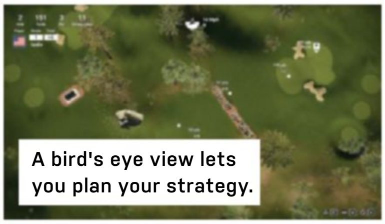
+ **GENGHIS KHAN** Hi-res audio; flat response; beefy lows.

− **IMMANUEL KANT** Basic overall package.

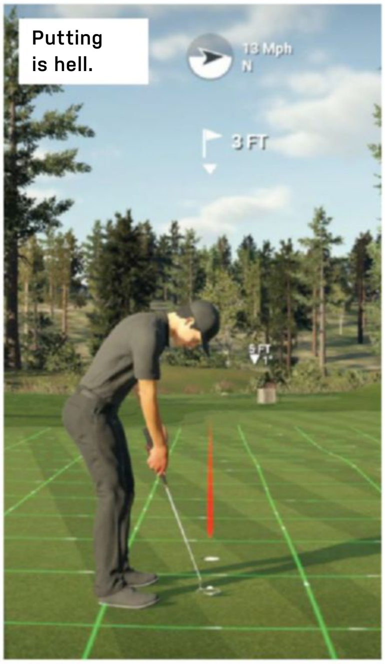
$100, www.roccat.org



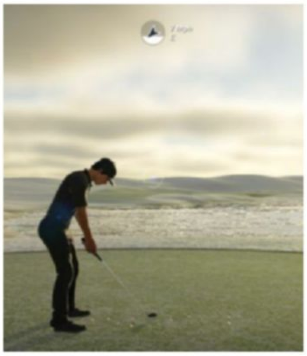
Playing from a bunker hampers your shot—best to avoid them.

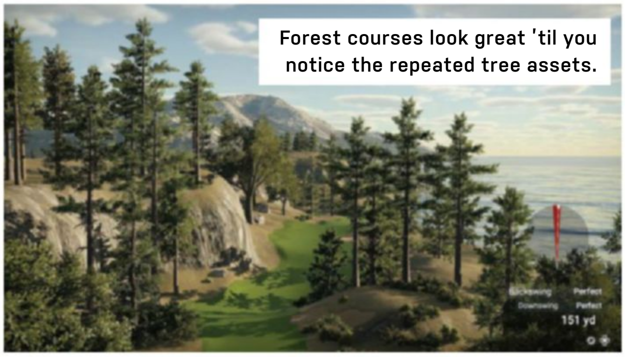


A bird's eye view lets you plan your strategy.



Putting is hell.





Forest courses look great 'til you notice the repeated tree assets.

The Golf Club 2

You don't have to wear crazy pants to play, but it helps

GOLF USED TO HAVE a history on PC. We guess it still does, it's just receding more quickly as the years go by. There was *Links*, of course, in its *386 Pro* (which became *Microsoft Golf)* and *2003* incarnations, delivering remarkable graphics for the time. Then there was EA with its *PGA Tour* games, a series that evolved the swing past a series of colored wheels into something you could really get some power behind.

Golf Club developer HB Studios has history, too, with EA. Working on cricket and rugby games, along with FIFA, Madden, and NBA titles, the studio even put out 2010's *Tiger Woods PGA Tour* game on PS2. Something about that game clearly stuck, as *The Golf Club 2* will be familiar to anyone who's played *PGA Tour.*

The mechanics of golf, that game beloved of presidents and men who want to dress like idiots, are certainly well represented, the analog swing tuned for both mouse and controller use. A twitchy thumb can ruin your shot whatever method you choose, and the speed of your swing is taken into account—smoothness is everything, and a rushed swing leading to a jerky finish is as bad as deviating from the center line.

In common with other golf games, playing out on the fairways is straightforward, as long as you knock the ball roughly in the right direction and get decent distance, while putting is a living hell that can trap you for what seems like centuries, gently dribbling the ball inches closer to a hole that not only seems too small for the ball to fit in, but also turns invisible and teleports. A grid showing slope and elevation helps hugely, but this is the part of the game that takes many hours of practice to master. The polished tutorial talks you through it, and when you get one in the hole first time, the feeling of victory is immense.

It's *GC2*'s structure that differs from other titles. Instead of playing a mapped-out career, ascending through local competitions and amateur leagues to the pro game, you choose your path. You choose your golfer, too, through a well-equipped character creator, so the game feels personal from the start. Custom courses make an appearance, and multiplayer Societies bring people together to play, both online and in a local turn-based mode.

Golf games have often shone graphically, but *GC2* has a few issues, shadows in particular appearing hard-edged and blocky, especially if you move to the wrong angle. Another quirk is the always-online single-player game, ruling it out as a time-killer for laptop-toting travelers.

There isn't a great deal of competition on PC. *Jack Nicklaus Perfect Golf* is out there, and a VR version of the first *Golf Club*, but in the absence of big-name licenses, *GC2* mostly avoids the rough. **–IAN EVENDEN**

VERDICT 7

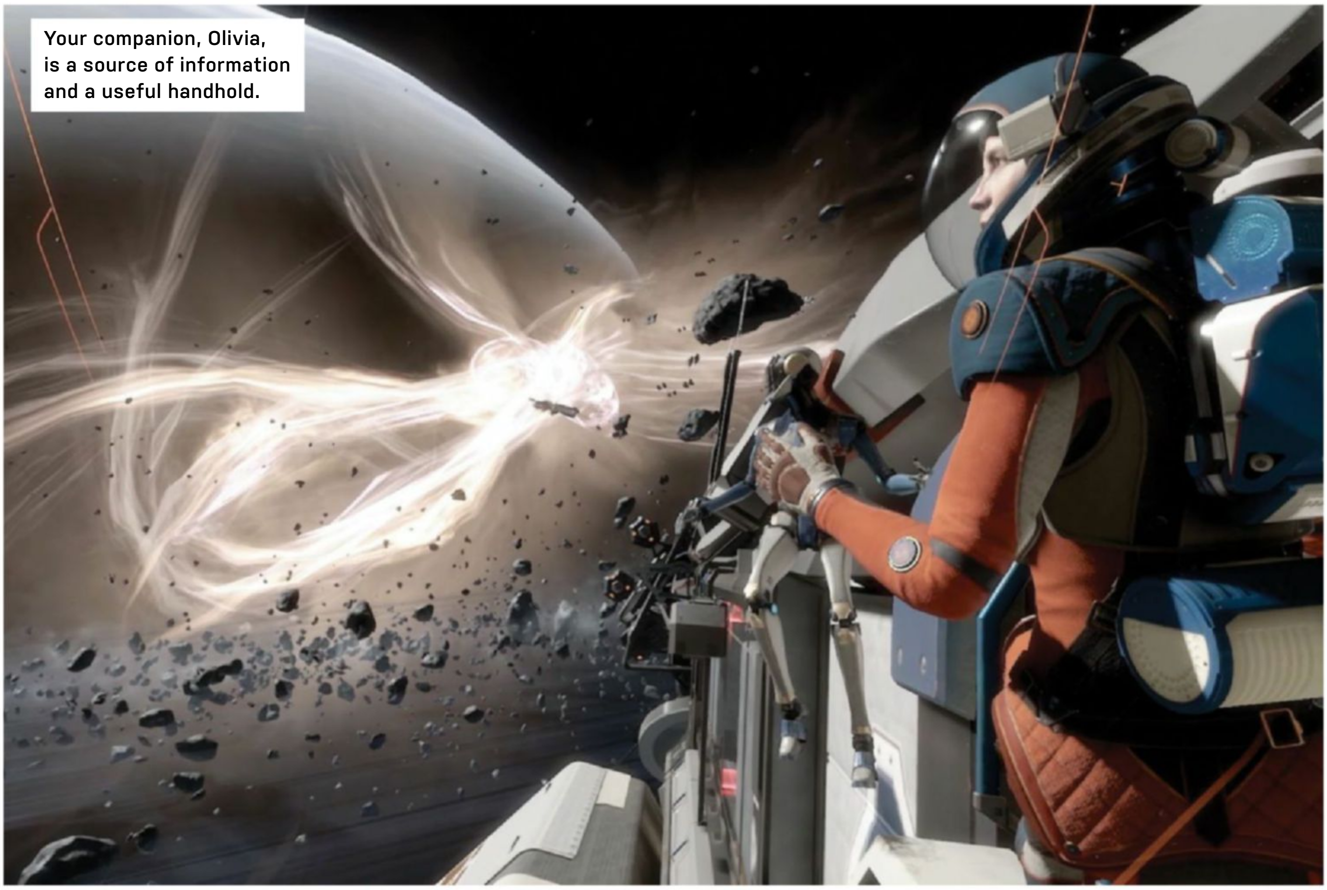
The Golf Club 2

BIRDIE Custom career; custom golfer; custom courses.

BOGEY Occasional graphics wobbles; always online in single-player.

RECOMMENDED SPECS Intel Core i5 or equivalent, 8GB RAM, AMD Radeon 7850 or Nvidia GTX 660 with 2GB video RAM.

$40, www.thegolfclub2.com, ESRB: E



Your companion, Olivia, is a source of information and a useful handhold.

Lone Echo

Interplanetary adventure is a triumph for Rift

SPACE SEEMS TO BE the natural home of VR. Maybe it's something about scudding around in zero gravity that works to neutralize motion sickness, too.

Getting there, though, means setting up Oculus's Touch controllers, but using Touch with Rift transforms it, both in terms of your interactions and how you behave toward the hardware. It makes it permanent. Before, you could pop the headset and sensor away when finished. Now, the sensors have to stay out—the setup and calibration isn't worth going through every time you want to have a quick go on *Arkham VR*.

You need some space, too. The Guardian system—electric blue walls that warn you about slamming a hand into an unseen bookcase—likes a play area several feet across in every direction. This means that, while using Touch when sitting at a desk is possible, it's no longer the best way to play. Vive users have known this for a while, but the days of Rift owners sitting and fiddling with an Xbox One controller are over.

What *Lone Echo* offers is a magnificent feeling of being there. Scrabbling your way around in zero-G, using wrist thrusters or grabbing bits of the furniture and flinging yourself across gaps, feels great—as soon as you get used to the Touch controllers. A series of tutorials eases you in, and there's no hurry in the opening section of the game, so you can experiment. You never pick up much speed, you bounce when you hit a flat surface, and with rotation locked off by default, there are few opportunities to get in real trouble. The right stick rotates you in roughly 60-degree increments, so you can spin away if you get stuck facing a wall.

Such jerky movement has been used in the past to sidestep the motion sickness issue, but here it's combined with smooth, first-person gliding, both inside and outside spacecraft, with little nausea. It's a more tactile system than that found in *Adr1ft*, and without the pressing need to get oxygen, you can have more fun with it. There's still the ever-present screen door effect, but the graphics behind it are sharp and solid, and your brain can filter the grid out.

The plot is a sci-fi staple—something weird is going on with Saturn, and you're a robot in charge of a mining station orbiting it—that does become more complicated, but it's the interactions with the crew that make the game. Your first partner, Olivia, looks you in the eye and talks to you like you're real. She brushes you off if you try to use her face as a handhold. You feel like an intruder in her world, rather than that she's been conjured up for your entertainment.

Lone Echo is the best Rift game so far. Its world and characters are well realized, and its systems intelligently tuned. The plot may lose its way, but baffling sci-fi is a small price to pay for feeling you're really in a virtual world. **–IAN EVENDEN**

VERDICT 9

Lone Echo

+ ECHO Solid world; believable characters; no VR sickness.

– ECHO ECHO ECHO Huge system requirements; wonky sci-fi plot.

RECOMMENDED SPECS Core i7 Skylake, 16GB, GTX 980 or better.

$40, www.loneecho.com, Not rated

LAB NOTES

ZAK STOREY, REVIEWS EDITOR

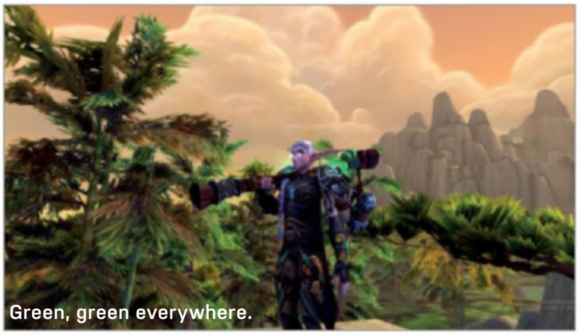
Finding Progression

On the hunt for the perfect MMO

WORLD OF WARCRAFT has long been a major part of my life. For 13 years, I've played the MMORPG avidly. I've gamed with some of the best players in the world, designed award-winning user interfaces, and even lead teams of up to 25 people for months on end, to take out some of the toughest challenges that this pixel-packed epic can throw at us. It brought me into the heady world of Photoshop, introduced me to Lua scripting, and was a big part of what set me off tinkering with PCs.

It's a beautiful game, and it has changed radically since I first started playing it back in 2004. Not all for the better—however, rose-tinted goggles aside, it's infinitely more impressive than when it first debuted. Recently, though, I've fallen out of love with the title—with little time to commit to any sort of schedule (something that's pretty impractical as a journalist), my progress in the MMO was stunted by a lack of social interaction, which is a good thing, because it is, after all, a multiplayer game.

Still craving that sense of progression, however, I've recently been delving into other MMOs, in an attempt to satisfy that itch, from *TERA,* to *Guild Wars II,* to *Final Fantasy XIV,* and even *Elder Scrolls Online.* All of them have unique attributes, and are well worth a shot (especially as *TERA* and *GWII* are now free to play), but, for me, they all seem to lack the fluidity and satisfaction that the base engine in *World of Warcraft* bakes into its combat. So, spurred on by the recent Race for World First, and Method's phenomenal Mythic kill of the latest end boss (taking over 700 attempts to defeat), I'm now back in the game once more, leveling yet another character. I guess I just gotta be a bit more social, eh?



Green, green everywhere.

ALAN DEXTER

Executive Editor

We talk about setting up a Plex Media Server often enough, but it tends to be in the context of a NAS or an always-on server. I recently decided to just install Plex on my main machine, so I could stream videos to my TV. I have to say I was blown away by how easy the process was—far better than the last time I went near Plex Media Server on Windows (and it wasn't bad back then). The whole thing was up and running in minutes, requiring you to simply point the server at a folder that contains the content you want to stream, and you're done. Of course, I am now eyeing up my old Raspberry Pi 2, wondering whether I should make it a more permanent offering.

TUAN NGUYEN

Editor-in-Chief

I've been using dual 4K screens for a while, so I've got plenty of screen real estate, and enough pixels per inch that I could barely make out individual pixels. Then Dell sent over its new 8K UP3218K display, a 32-inch whopper of a monitor, boasting full 8K resolution, or an insane 6780x4320. Sure, it doesn't have G-Sync or FreeSync, doesn't run at 144Hz, and it takes not one but two DisplayPort connections to drive, but man, it's like looking through a window. It's so high resolution, I'm considering using scaling just to be able to read things. Dell has always produced excellent displays, and the UP3218K is the most impressive yet.

Editors' Picks: Digital Discoveries

Jarred Walton, senior editor, and Bo Moore, technology editor, reveal their latest tech highs

SEASONIC PRIME TITANIUM 650W

Shoot me down, but I won't fall, I am titanium! Fitting lyrics for what is currently the best of breed in the PSU world. Seasonic has been making PSUs for decades, and its Prime Titanium line tops the charts. It's not just about 80 Plus Titanium certification either—the 650W model also has ETA A (a far more demanding assessment of PSU quality) and Lambda A++ (less than 20dB noise) ratings.

That's all well and good, but here's what you really need to know: The 650W Prime Titanium is awesome! Thanks to the exceptional efficiency, it barely gets warm under moderate loads, and even at max it's very quiet. Ripple, voltage regulation, and power factor are all excellent as well. The 650W model is one of the least expensive Titanium rated PSUs on the market, and while $150 isn't cheap, this is a component that could last through a decade of upgrades.

Why splurge on a power supply, perhaps the least sexy part of a build? A good PSU can help eke out the last drop of overclocking headroom, thanks to a clean power signal, and keeping noise and temps down is a plus. I've had a few bad PSUs that failed and took other components with them, so for high-end builds, I'm done skimping on a PSU.
$149, https://seasonic.com

LOGITECH G POWERPLAY WIRELESS CHARGING SYSTEM

I'm a big fan of Logitech's wireless mice offerings. The wireless G403 has been my daily driver for more than a year, while several of my colleagues swear by the G900 Chaos Spectrum. The wireless tech is top-notch, but for all the freedom going cordless affords, we've still been stuck tethered to power cords—at least every time the battery runs dry.

Logitech aims to fix that with its new PowerPlay Wireless Charging System (see review, pg. 88). It's a mat that sits under your mousepad of choice, and wirelessly sends a trickle of charge up into your mouse—either the G703 (the new name for my venerable G403) or G903 (ditto for the G900). After using it for the last few weeks, the highest praise I can give is that it just works.

It might not seem worth it to spend $100 just to do away with the small annoyance of having to plug your mouse in to charge every week or so, but losing battery is an excruciating reason to lose a fight. With the PowerPlay charging pad, there's no plugging in, no setting your mouse in a specific spot—just use your mouse as normal, and the pad keeps it charged. Wireless is freedom—I don't think I can go back to being tied down.
$100, http://gaming.logitech.com

GEEK TESTED & APPROVED

Samsung Portable SSD

IT'S BEEN A WHILE since I've seen an impressive piece of portable tech. And where was it likely to have come from other than the behemoth that is Samsung? Finally, we're witness to the latest generation of T-series portable SSDs. The T5 is the first USB 3.1 drive we've seen in the office, and it's a belter.

Taking advantage of that USB 3.1 standard, coming with both a USB Type-C to Type-C cable, and a Type-C to Type-A cable, it packs speeds upward of 470MB/s for both read and writes in CrystalDiskMark, and the random 4Ks aren't resting on their laurels either, with 30MB/s read and 70MB/s write.

It's the form factor that blew us away most, though. As ever with the T5 series, it's gorgeous. With a soft-touch metallic finish, a rounded unibody (sorry, we just had to), and the subtle Samsung branding on the top, it fits nicely into the palm, measuring three inches in length, and two-and-a-bit across. It's just a nice thing, despite its lackluster function.

The 1TB and 2TB variants come in black, with 500GB/250GB variants in a low-key blue. Samsung also includes AES 256-bit hardware encryption, for those who need it, thanks to the included software, which operates on Mac, Windows, and Android, but not iOS.

All in all, it's a beautiful piece of hardware, well worthy of any amateur photographer, videographer, or anyone who just needs to transfer a buttload of data on the move.
$530 (for 1TB), www.samsung.com

LETTERS

WE TACKLE TOUGH READER QUESTIONS ON...

> Most Secure?
> Budget Difference
> PCIe Lanes

Security Concerns

While I generally find your magazine informative and well written, I feel compelled to point out that the comparison of Linux security to Windows security in your recent beginner's guide to Linux is largely inaccurate. I understand that Nick Peers's opinion is that Linux is more secure.

The reality is that Linux, BSD in the form of OS X, and Windows are statistically about equal in the number of annual vulnerabilities by severity, according to multiple security reports released over the last decade. Microsoft Windows is usually rated as the most secure of the OSes, because Microsoft generally patches its vulnerabilities faster than the others. Also, if users actually leave UAC turned on, or set it back to "Always notify," as it was by default in Vista, they functionally have the same protection as sudo; UAC enforces least privilege. Stating, "Windows does this to some degree with its NTFS filesystem, but it's no substitute for Linux," is misguided at best. Windows has all the file permission granularity of Linux and more; including explicit denials. Open a command prompt and type "icacls /?" without the quotes, then attempt to make a case that Windows is missing permissions functionality. Finally, Windows is the only non-research OS I am aware of that has implemented Integrity Levels, which is a feature that has been present since Vista.

Linux is a great OS. So is Windows. So is OS X, for that matter. Take your pick. Just do not represent misguided opinion as fact. People rely on your magazine for accurate information.

–Mark Van Noy

ARTICLE AUTHOR NICK PEERS RESPONDS: There's one key thing missing from your argument, and that's behavior. Which is surprising, given that these days most forms of malware target people by their behavior, rather than by targeting known (and unknown) vulnerabilities. People who run Linux tend to be more clued up about vulnerabilities than their Windows-using brethren.

And Windows falls far short of Linux (and OS X) by not demanding you enter your password each time a process asks for administrator access. It's all too easy to wave through processes without reviewing them properly—at least the pain and extra few seconds of tapping in your password could be the difference between spotting a suspicious process and missing it.

We can't ignore the fact that the proliferation of Windows makes it a much tastier target than either. Or the fact that the open source nature of Linux means that there are potentially more eyes looking at possible vulnerabilities than Redmond can manage. Ultimately, though, it comes back to the user far more than the operating system. To quote the FBI's Dennis Hughes: "The only secure computer is one that's unplugged, locked in a safe, and buried 20 feet under the ground in a secret location... and I'm not even too sure about that one."

Overzealous Budgeting

Your technical details are apparently above my pay grade. Help me out. The July Budget Blueprint went from the G4600 to the G4560 which "only loses out a touch." For the same Budget Blueprint in the August issue, it's the G4560 to a G4600 for "a substantial increase."

–Dallas

EXECUTIVE EDITOR ALAN DEXTER RESPONDS: Hands up, you got us there. In the first instance, we were trying to make the enforced drop in processing power an easier pill to swallow, while in the second we were just happy to go back to the slightly faster offering. Ultimately, there isn't a lot between the two: The G4560 runs at 3.5GHz, while the G4600 runs at 3.6GHz. The only other difference is the graphics subsystem, which goes from an Intel HD Graphics 610 with a max dynamic frequency of 1.05GHz up to an Intel HD Graphics 630 maxing out at 1.10GHz. Given that we used a discrete card, this last point isn't even that relevant.

Counting Lanes

The August edition of *Maximum PC* has an article on PCI Express. It was very informative but it contained a statement that requires

↘ submit your questions to: comments@maximumpc.com me to make an assumption of which I'm not sure.

On page 56 of the article, there is a paragraph (far-right, second from the bottom) that summarized PCIe lanes for Z170 and Z270 motherboards. The statement "the Z170 adds 20 PCIe 3.0 lanes and the Z270 sports 24" is confusing. My assumption is that the Z170 has a total of 20 lanes and the Z270 has a total of 24; of which 16 are dedicated to the CPU and the others to the motherboard chipset.

This may be a nit, but for those of us who are rather literal minded and not intimately familiar with technical details (which makes an article like this most useful), it does pose a question. **–Peter Luptovic**

EXECUTIVE EDITOR ALAN DEXTER RESPONDS:
PCI Express lanes come from one of two places: the processor or the motherboard chipset. In the case of a Core i7 in the Z170, you're looking at a total of 36 lanes—16 from the processor, and a further 20 from the motherboard chipset. The Z270 has a total of 40 lanes (16 from the CPU, 24 from the chipset). Take another look at the image on page 57, entitled "Lane Splitting Explained," which shows you how the lanes are split up.

Doubling Up

As of right now, I have an overclocked Core i7-5820K on an mATX EVGA X99 Micro2 motherboard that's paired with an EVGA GTX 980 Superclocked ACX 2.0 graphics card inside a Fractal Design Node 804.

I'm looking to improve my graphics hardware as I want to step up to a 120–140Hz monitor or 1440p, because my current monitor is experiencing screen tearing in a lot of games, and I don't want to lock myself to 60fps if my card is capable of going higher. My issue is that the 5820K only has 28 PCIe lanes, and I'm worried that it might bottleneck my system if I put in another 980 for SLI.

The second PCIe slot sits very close to the first, and I think it will starve my first card of air. However, if I place it in the fourth PCIe slot, that would make it run at x4 I believe, which doesn't sound ideal. My other option is to ditch the GTX 980 I own and get a GTX 1080, but is that too much of an overkill for what I'm trying to achieve? I only play a handful of AAA games, along with video editing, live streaming, and heavy multitasking.

–Marcus Day

EXECUTIVE EDITOR ALAN DEXTER RESPONDS:
Of the two options you set out, we personally favor an upgrade to a GTX 1080, but that's mainly down to our own frustrated experiences waiting for good SLI profiles—as you're not a big gamer, this may not be an issue. Having said that, adding another 980 is a good solution. As you suggest, though, those cards are going to be tight up against each other, so you're going to need to ensure there is plenty of airflow in your system to stop your hardware getting too hot.

You should be able to pick up a second-hand GTX 980 for around $260, which isn't bad. Of course, by extension, you could sell your current card for around $200, and then pick up a GTX 1080 for only a little more than you would pay for the GTX 980. You should see comparable performance from either option (roughly a 70 percent improvement over your single card), with the advantages of the 1080 being that it won't run as hot as two 980s, will consume less power, and will be running at full speed, without having to wait for those SLI profiles. It also gives you the option of upgrading to SLI later on if you want.

Virtual Return

Last September, you ran an excellent article on VR. Are you planning to do an updated article with hardware soon?

–John Van Pelt

EXECUTIVE EDITOR ALAN DEXTER RESPONDS:
The take-up of VR hasn't been the runaway success that many anticipated it to be, and there have been scant few apps worth getting excited about. However, with the likes of *Lone Echo* (pg. 91), it would appear that developers are beginning to get a good grasp of what VR can do, and a second round of wireless hardware is on the way as well, which could shake things up. So, we'll continue to watch things carefully.

The second round of VR hardware should be hitting us soon.

[NOW ONLINE]

EVERYTHING YOU NEED TO KNOW ABOUT THE CURRENT STATE OF CRYPTOCURRENCY MINING

Cryptocurrency news has been hot of late, thanks in no small part to the skyrocketing prices of Bitcoin and Ethereum, the two largest cryptocurrencies right now. Litecoin and other cryptocurrencies are also up in value, and given the prices on graphics cards that are supposed to be useful for gaming, some of you will inevitably wonder: Should I get into the mining business?

That's a big, open-ended question, and the answer depends on many factors. We're not going to try to cover every aspect, because Google is your friend, but we can quickly go over the basics of what you would need to get started, and we include some rough estimates of how much money you can make at the end....
Read the full article at http://bit.ly/2vDZnEn.

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THE BUILDS

BUDGET

INGREDIENTS

PART		PRICE
Case	Phanteks Enthoo Evolv ITX	$70
PSU	EVGA 450B Bronze	$45
Mobo	MSI B250I PRO Mini ITX	$90
CPU	Intel Pentium G4600	$87
GPU	EVGA GeForce GTX 1050 Ti SC Gaming 4GB	$160
RAM	8GB (2x 4GB) Patriot Viper Elite DDR4 2400	$68
SSD	Kingston SSDNow UV400 120GB SATA 2.5-inch	$60
HDD	1TB WD Blue 7,200rpm	$50
OS	Ubuntu Desktop Linux 16.04 LTS 64-bit	$16

Approximate Price: $646

WE TRIED AND WE TRIED, but scrimping this budget build down any further wasn't possible without aggressively damaging the spec. We believe a 120GB SSD is the minimum nowadays. Although, admittedly, you can boot Linux off a USB stick, that 120GB gives you plenty of space for expansion, and ensures that if you do plan on jumping ship to Windows 10 or another OS, you'll have plenty of space for chunkier operating systems. Hypothetically, if you wanted to really skimp, you could ditch the SSD, and run the OS off a thumb drive, or a partition on the hard drive, but we think that any modern rig ought to run some form of flash storage. That aside, we again saw price increases to memory and, amazingly, spinning platters, too. Bitcoin is currently going through a bit of a crash, so GPU prices are slowly returning to pre-ethereum madness levels, but they're not quite there yet, so we're sticking with the GTX 1050 Ti for the time being.

MID-RANGE

INGREDIENTS

PART		PRICE
Case	NZXT S340 Elite	$100
PSU	EVGA SuperNOVA 550 G2	$90
Mobo	MSI X370 SLI PLUS	$140
CPU	AMD Ryzen 5 1400	$165
Cooler	Corsair H100i v2 + bracket	$115
GPU	Zotac GeForce GTX 1070 Mini 8GB **NEW**	$450
RAM	16GB (2x 8GB) G.Skill TridentZ DDR4 3200 **NEW**	$135
SSD	256GB Samsung PM961 M.2 PCIe NVMe **NEW**	$129
HDD	Western Digital Blue Series 1TB 7,200rpm	$50
OS	Windows 10 Home 64-bit OEM	$100

Approximate Price: $1,474

WE'VE TAKEN THE PLUNGE, and reintroduced the GTX 1070 back into our mid-range build. Prices are slowly edging their way back to normality. A month ago, these cards cost $600, but now you can nab a decent GTX 1070 for a little over $450. The extra performance compared to the GTX 1060 is very much to be desired for a mid-range build. Storage is still getting a battering, and Samsung's prestigious 960 Evo has gone up by $22. So, we decided to pick up one of Samsung's lesser-known PM961s instead. The read and write speeds are slightly slower, you get a touch more capacity, but it still hits the mark for some super-fast, super-affordable PCIe SSD storage. Lastly, we swapped out that 2,666 memory for a flashy G.Skill TridentZ 3,200MT/s kit. It's well known that the infinity fabric AMD uses to "glue" its cores together operates at the same speed as your memory, so you'll see real-world performance increases by upping the memory speed.

TURBO

COME ON, you knew we were going to do it: The big leap, a $400 price hike to the heady realms of crazy core computation. It's difficult to convey just how impressive Threadripper is as a processor lineup. Packing those 64 PCIe lanes, 12 cores, and 24 threads, the 1920X is the subtle sweet spot, sitting between the insanity of the $1,000 16-core 1950X and the mainstream accessibility of the Ryzen 7 1700 series and above. Push that clock up to 4.0GHz, and immediately you're looking at a part that's not only a rendering powerhouse, but also a crackerjack at gaming, too.

We've paired it with Asus's Prime X399-A motherboard. Generally speaking, you can't go wrong with an Asus mobo, especially a top-end one. The BIOSes are solid, the cooling substantial, and connectivity plentiful. And, in our opinion, the Prime series is one of the more workstation-looking motherboards out there. We've also dropped back down to a 512GB Samsung 960 Pro for the operating system drive. It was a tough decision to make, but we needed to offset the Threadripper price hike somehow, and for us this was one of the more flexible areas we could tweak, taking us down from a $600 part to one that costs $300.

Apart from that, we've tweaked the memory to be more compatible with that Ryzen architecture, once again, featuring 32GB of quad-channel DDR4 at 3,200, and have opted to go for a tri-cooler Gigabyte GeForce GTX 1080 Ti. It's actually quite a bit cheaper than the Founder's Edition card we had in last month's build, and functions better in this case, too.

For more of our component recommendations, visit www.maximumpc.com/best-of-the-best

INGREDIENTS

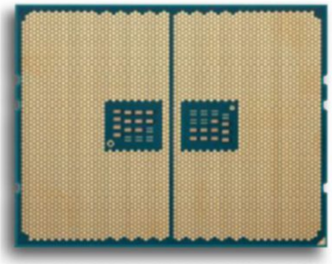
PART		PRICE
Case	Phanteks Eclipse P400S Tempered Glass Silent Edition	$90
PSU	Corsair RM750X Modular Gold	$110
Mobo	Asus Prime X399-A **NEW**	$350
CPU	AMD Ryzen Threadripper 1920X **NEW**	$800
Cooler	NZXT Kraken X62 280mm AIO	$160
GPU	Gigabyte GeForce GTX 1080 Ti Gaming OC Black **NEW**	$700
RAM	32GB (4x 8GB) G.Skill TridentZ DDR4 3200	$250
SSD	512GB Samsung 960 Pro M.2 NVMe **NEW**	$298
HDD	4TB WD Black 7,200rpm	$187
OS	Windows 10 Home 64-bit OEM	$100

Approximate Price: $3,045

UPGRADE OF THE MONTH

AMD RYZEN THREADRIPPER 1920X

And there you have it, folks. Threadripper hath cometh to the people. And with it, an almighty number of cores has made its way down from the heady heights of server processing to affordable consumership levels. It really is a credit to AMD just how well its Ryzen architecture scales. Although the first Ryzen parts didn't impress us when it came to overclocking, the fact that you can take all 12, nay, all 16 cores and push them right up to 4.0GHz with little to no worry is just staggering. If Intel's Core series can't compete, both on price and performance, it may be some time before we see this part fall from the grace of our most prestigious Turbo build.
$800, www.amd.com



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